ERDC SR-12-2, Supplement 2

Engineer Research and Development Center

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The US Army Corps of Engineers Roadmap for Life-Cycle Building Information Modeling (BIM)

Supplement 2 – BIM Implementation Guide for Military Construction (MILCON) Projects Using the Bentley Platform

Prepared by Bentley Systems, Inc.

685 Stockton Drive
Exton, PA 19341

November 2012

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Final report

Prepared for US Army Corps of Engineers
Washington, DC 20314-1000

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3909 Halls Ferry Road, Vicksburg, MS 39180

Abstract

Building Information Modeling (BIM) technology has rapidly gained acceptance throughout the planning, architecture, engineering, construction, operations, and maintenance industries. The challenge for the US Army Corps of Engineers (USACE) is to extend BIM use beyond its basic labor- and time-saving benefits to become a fully realized information network that permanently transforms conventional business processes to unprecedented levels of efficiency and organization.

This document describes the current USACE strategic plan, reflecting progress made toward the goals of the original 2006 USACE BIM roadmap as published in Engineer Research and Development Center (ERDC) Technical Report TR-06-10 (October 2006). This update of the strategic roadmap focuses on fuller integration of BIM technologies into USACE planning, design, construction, and operations and maintenance (O&M) processes. It describes how USACE will meet or exceed the vision of its customers, including the Office of the Secretary of Defense (OSD), the Army, and the Air Force. The scope of this plan is BIM implementation within the business processes of the Military Construction (MILCON) and Civil Works programs, including processes for working with USACE industry partners and software vendors.

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Preface

This document was prepared for Headquarters, US Army Corps of Engineers (HQUSACE), as a supplement to Engineer Research and Development (ERDC) Special Report SR-12-2, *The US Army Corps of Engineers Roadmap for Life-Cycle Building Information Modeling (BIM)* (November 2012). The text was authored by Bentley Systems, Inc., Exton, PA, for government personnel, contractors, and stakeholders using Bentley software tools on Military Construction (MILCON) projects supervised by USACE. This supplement is a reprint of the original edition, dated January 2011, but is revised to include accurate cross references to the USACE 2012 updated BIM Life-Cycle Roadmap. This publication reflects a vendor-neutrality policy in support of commercial partners involved in USACE BIM implementation and project execution. Supplements pertaining to other vendors' technology products for MILCON and Civil Works projects are available or are in preparation. The proponent for the USACE Building Information Modeling Roadmap is the Directorate of Civil Works, Engineering and Construction Branch. The Technical Monitor is Jason C. Fairchild, CECW-CE.

Development and update of this guide were coordinated through the Engineering Processes Branch (CF-N) of the Facilities Division (CF), US Army Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC-CERL); and the CAD/BIM Technology Center (IS-C) of the Software Engineering and Informatics Division (IS), Information Technology Laboratory (ERDC-ITL). At the time of publication, Donald K. Hicks was Chief, CEERD-CF-N; L. Michael Golish was Chief, CEERD-CF; Dr. Kirankumar Topudurti was the Deputy Director; and Dr. Ilker Adiguzel was the Director of ERDC-CERL. Edward L. Huell was Chief, CEERD-IS-C; Ken Pathak was Chief, CEERD-IS; Dr. Kevin M. Barry was the Acting Deputy Director; and Dr. Reed L. Mosher was the Director of ERDC-ITL.

The following individuals are acknowledged for their contributions to the preparation and technical review of this report:

- Brian Huston (Bentley Systems, Inc.)
- Steve C. Spangler, CEERD-IS-C
- Beth A. Brucker, CEERD-CF-N.

COL Kevin J. Wilson was the Commander of ERDC, and Dr. Jeffery P. Holland was the Director.

1 Introduction

1.1 Background

This document was authored by Bentley Systems, Inc. It is intended to serve as a reference for all USACE Districts, BIM Managers and architectural/engineering firms working with USACE on Military Construction (MILCON) projects using the Bentley platform. The purpose is to ensure that users have the information needed to comply with the Building Information Modeling (BIM) implementation and business transformation goals established by Headquarters, USACE. This reference guide provides an example of BIM in practice, project setup suggestions, and Bentley lessons learned through project experience with USACE. The main goal of this document is to help new project teams leverage the benefits of related Engineer District BIM production, organizational collaboration, and contractor acquisition experiences. A secondary goal is to provide insight into making BIM a more integrated part of MILCON execution and a more comprehensive facility life-cycle information management tool for planning, design, construction, and installation operations.

This November 2012 edition of the Bentley Systems implementation guide is identical to the original edition of January 2011 except for updates of ERDC administrative content and cross-references to associated USACE documents and websites. As such, this edition supersedes the 2011 version and should be used in its place.

1.2 Bentley BIM Applications

Bentley's multidisciplinary suite of BIM products enables project participants to work together in an integrated and collaborative process. Each discipline-specific product provides support for design, construction and operations contributing to a “federated” BIM (Figure 1). This federated approach permits individual practitioners to create and manage their discipline-specific designs while referencing all other disciplines and contributing to a communal master model.

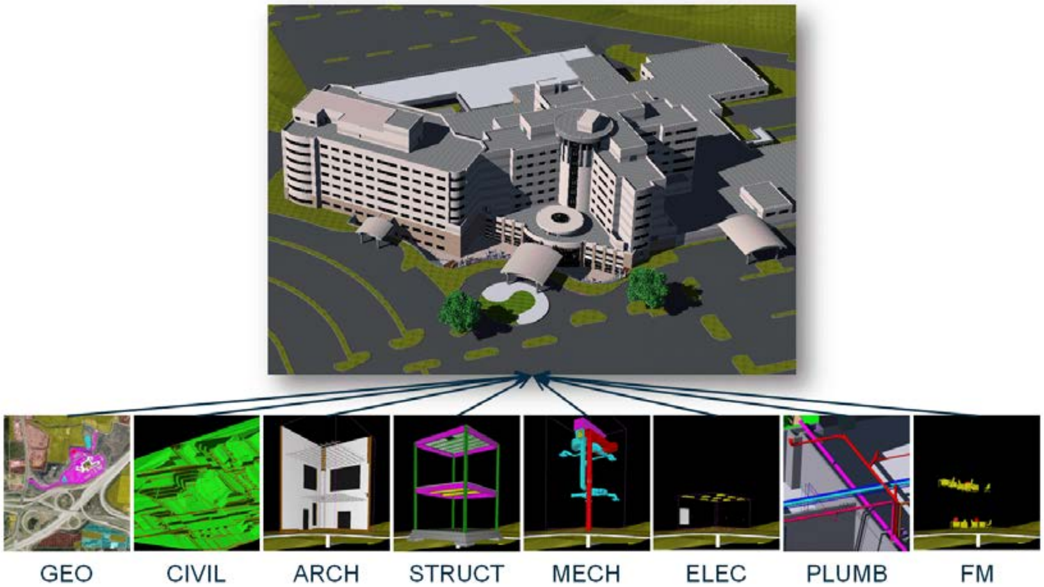


Figure 1. Federated BIM.

1.3 Previous Bentley BIM Applications for USACE

BIM has successfully been used on many USACE projects. A few reference projects include:

	Project Title	District	Facility Size (sq ft)	Disciplines
1	Regional Logistics Support Complex - Tactical Equipment Maintenance Facilities	Seattle (In-house and AE)	TEMF 1 - 71,955 TEMF 2 - 83,563 OSB 1 - 4,486 OSB 2 - 4,486	Civil, Landscape Architecture, Architecture, Interior Design, Structural, MEP, Fire Protection, Telecommunications
2	Whole Barracks Renewal, Stryker Avenue - Company Operations Facility	Seattle (AE)	Admin bldg - 16,140 Readiness bldg - 36,058	Civil, Architecture, Structural, Fire Protection, MEP, Telecommunications
3	USAR 81st RRC ARC/OMS/UHS - Raleigh-Durham, NC	Louisville (in-house)		Architecture, Interior Design, Structural, MEP
4	AR 88th RRC General Purpose Warehouse – Ft. McCoy, WI	Louisville (in-house)		Architecture, Interior Design, Structural, MEP
5	USAR 77th RRC AFRC - Niagara Falls, NY	Louisville (in-house)		
6	Ft Bragg Whole Barracks Renewal	Savannah	2 Buildings totaling 209,000 sq ft	Arch, Struct, MEP, Fire, Civil
7	Ft Bragg Whole Barracks Renewal COF	Savannah	2 Buildings totaling 60,000 sq ft	Arch, Struct, MEP, Fire, Civil
8	Ft Bragg Whole Barracks Renewal COF Butner Rd	Savannah	3 Buildings totaling 50,000 sq ft	Arch, Struct, MEP, Fire, Civil

2 Bentley Implementation Workflow

This chapter describes a methodology for using software applications and data interoperability that should be considered when developing a MILCON project using information modeling. The intent of this section is to provide visual examples of design and analysis tools that overview new project delivery methods and review practices which exploit the use of information modeling and data management solutions.

2.1 Site Analysis

The development of a site master plan helps to determine if a candidate site will support the building program requirements and guide design decisions to optimize site features. The design process requires the review of adjacent property use, zoning requirements, topographical data and environmental impacts (Figure 2). Using integrated GIS, imaging, map projection tools, the architect, civil engineer and owner can evaluate: options for building placement, the influence of the site features (Figure 3), and the impact of transportation considerations such as vehicular access.

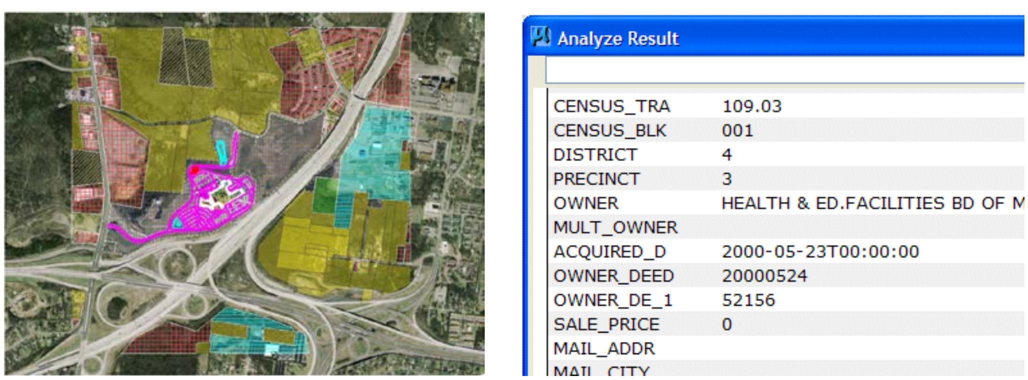


Figure 2. Master Plan and Property Data Window.

Figure 3. Aerial Map with Survey Data.

- Bentley Map: http://www.bentley.com/en-US/Products/Bentley+Map/

2.2 Utility Locations

Site analysis continues with the documentation of existing utilities and proposed placement of new utilities (Figure 4). As the overall site and building are defined, the existing utilities will need to be reviewed and an assessment made as to whether there is sufficient capacity (Figure 5) to support the new building and the requirement for new utilities. Based on the building location on the site, the point of entry for the utilities into the building will be negotiated based on the use of integrated mapping and civil analysis to optimize civil infrastructure improvements.

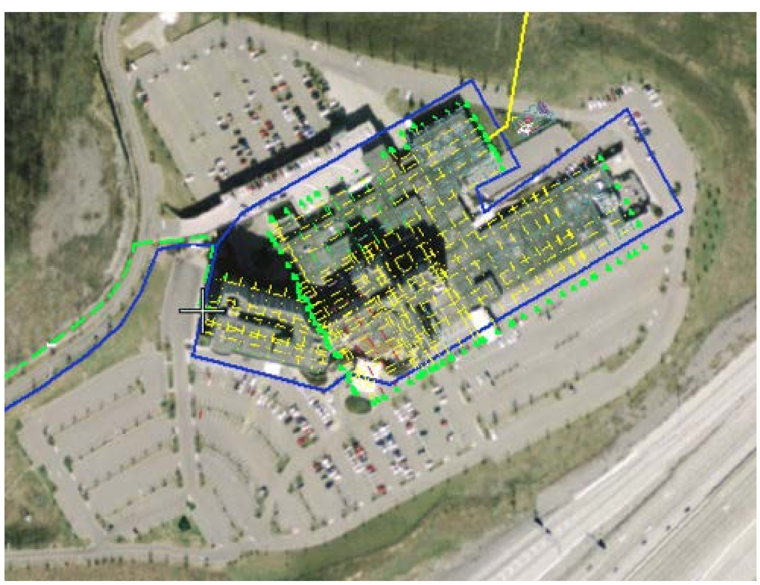


Figure 4. Aerial Map with Utilities.

gas_main	
Property	Value
pressure	Low
install_date	
input_technician	David.Shearon

ug_secondary	
Property	Value
voltage	240/480
conductor_size	3/0
conductor_type	CU
install_date	

telco_cable	
Property	Value
asbuilt_length	
type	Fiber
msd	value
install_date	
length	970.371715

Figure 5. Utility Data.

- Bentley Water: http://www.bentley.com/en-US/Products/Bentley+Water/
- Bentley Gas: http://www.bentley.com/en-US/Products/Bentley+Gas/
- Bentley Electric: http://www.bentley.com/en-US/Products/Bentley+Electric/
- Bentley Fiber: http://www.bentley.com/en-US/Products/Bentley+Fiber/

2.3 Civil Infrastructure

The decision of the building location will be influenced by surveys, soils reports, and earth movement requirements (Figure 6). Local municipality codes will define requirements for storm water control and retention that may require the use of berms, swales or water retention ponds. Other site considerations include taking greater advantage of landscape features (i.e., natural habitat areas, rock outcroppings, views and solar orientation). The use of civil site design analysis tools can add efficiency to the topographical design including the design of roadway access for general use, building delivery and maintenance and parking lot layout (Figure 7).

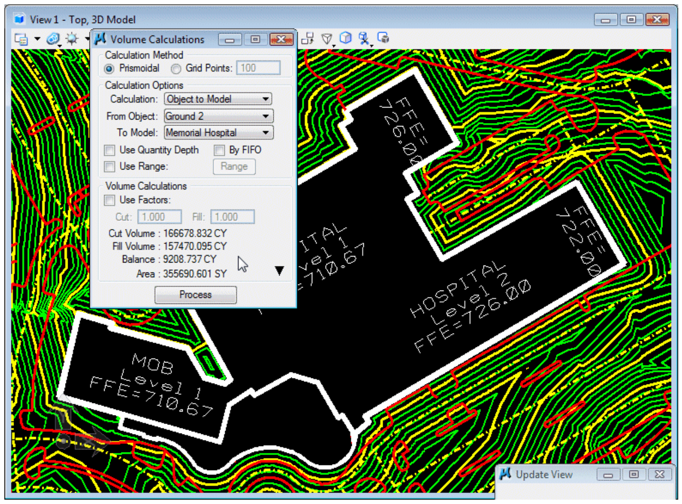


Figure 6. Earthworks, Cut and Fill Calculations.

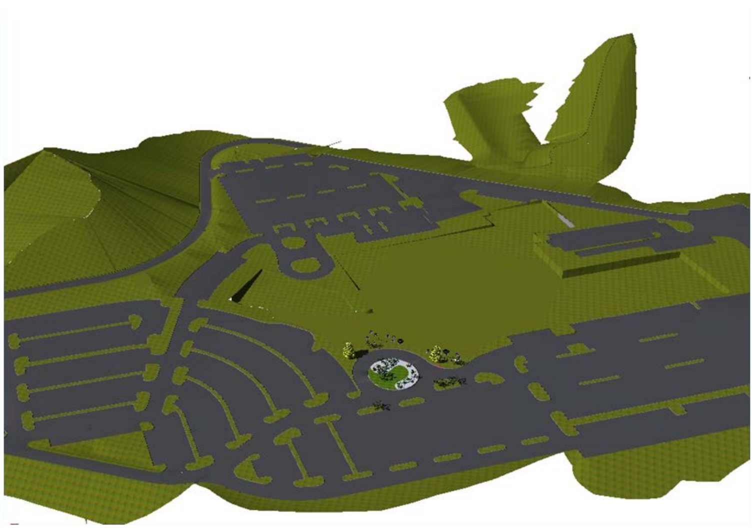


Figure 7. Site Final Grading, Roads and Parking.

- GEOPAK Civil Engineering Suite: http://www.bentley.com/en-US/Products/GEOPAK+Civil+Engineering+Suite/
- InRoads Suite: http://www.bentley.com/en-US/Products/InRoads+Suite/

2.4 Space Programming

A building space program (Figure 8) defines the space requirements (i.e., functional use, square footage, utilities, finishes, etc.), the relationship between the spaces based on organizational needs, or any special requirements of the building. The building program is used to develop preliminary space layouts and circulation patterns (Figure 9). The development of a building massing model (Figure 10) begins to articulate the building form. During this phase of design, space reports can be used to validate the design against the building program requirements and perform preliminary cost analysis based on functional areas and costs per square foot calculations.

SPACE PROGRAM
Conceptual Square Foot Estimate

DEPARTMENT		REVISED DGSF
OPERATIONS & ADMIN.		
Admin. & Bus. Ofc./Acct/HR/QA/DR's Lounge		10,135
Medical Records/IS		6,032
Education/Conference		4,852
SURGICAL SERVICES		
Pre-op/Recovery		16,363
Surgery/Special Procedures		23,463
Central Sterile Supply		4,607
PATIENT CARE SERVICES		
Med/SurgA (All Private)		63,968
ICU & Step-Down Unit/RT		12,755
Women's Services		19,549
Specialty Units:		
Observation Beds, Licensed		
Telemetry		
Skilled Nursing		21,577
Psychiatric		0
Pediatric		
CRITICAL CARE		
ED-Triage/Emergent/Urgent/Observation		13,854
DIAGNOSTICS & THERAPY		
Lobbies & Admitting		10,598
Light Diagnostics		6,390
Heavy Diagnostics		20,662
Oncology Services		8,950
Physical Therapy/Cardiac Rehab		3,985
Medical Oncology		2,148
Sleep Lab		1,458
Dialysis		595
CENTRAL SUPPORT		
Lab		5,538
Materials Mgmt		3,071
Pharmacy		2,823
Food Service		10,290
Housekeeping		2,919
Maintenance		2,919
Powerhouse	x$120	8,692
TOTAL DGSF:		288,194
Circulation	8.40%	24,208
Building Systems	3.30%	10,309
Walls,canopies etc.	4%	12,908
TOTAL BGSF:		335,620

Figure 8. Space Program.

Figure 9. Block Plan.

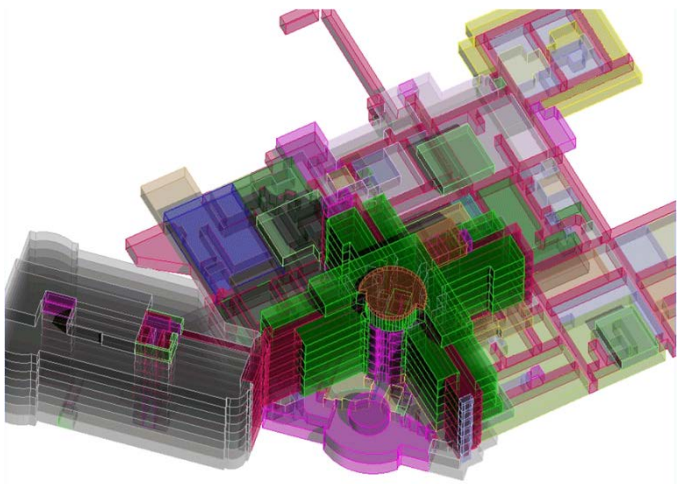


Figure 10. 3D Massing Model.

- Bentley Architecture: http://www.bentley.com/en-US/Products/Bentley+Architecture/

2.5 Architectural Design

Architectural design begins with preliminary building massing models, continues with building core and shell design, the layout of interior spaces and construction detailing. The use of generative design offers a more efficient means of introducing an iterative process to evaluate multiple design options. Using architectural design tools for the placement of assets (i.e., furniture, fixtures and equipment) provides data for facilities management. The development of the architectural BIM model (Figure 11) provides the basis for coordination of all other disciplines (i.e., structural, mechanical, electrical, plumbing). The use of the architectural design application streamlines the creation of plans, sections, elevations and details. Renderings and animations provide for visualization to evaluate building materials (Figure 12) and the organization and quality of space.

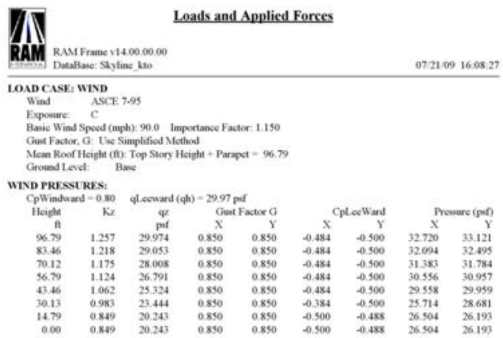
Figure 11. Architectural BIM.

Figure 12. BIM Rendering.

- Generative Components: http://www.bentley.com/en-US/Products/GenerativeComponents/
- Bentley Architecture: http://www.bentley.com/en-US/Products/Bentley+Architecture/

2.6 Structural Engineering

The integration of the structural system with the architectural begins to form the building and creates opportunities for the structural system to contribute to the expression of the building. The structural engineer begins the definition of a structural analysis model after the review of the architectural schematic design, site and soil conditions and code requirements. The use of structural analysis computation (Figure 13) allows the engineer to evaluate multiple options for the structural system. The analysis model is then transitioned to a physical model representation to coordinate with other disciplines (i.e., architectural, mechanical, electrical and plumbing). Structural detailing applications (Figure 14) allow for efficient construction detailing, cost estimating and data exchange. This efficiency reduces waste and cost during the fabrication process.



Loads and Applied Forces

RAM Frame v14.00.00.00
DataBase: Skyline_kto 07/21/09 16:08:27

LOAD CASE: WIND
Wind ASCE 7-95
Exposure: C
Basic Wind Speed (mph): 90.0 Importance Factor: 1.150
Gust Factor, G: Use Simplified Method
Mean Roof Height (ft): Top Story Height + Parapet = 96.79
Ground Level: Base

WIND PRESSURES:
CpWindward = 0.80 qLeeward (qh) = 29.97 psf

Height	Kz	qz	Gust Factor G		CpLeeWard		Pressure (psf)	
ft		psf	X	Y	X	Y	X	Y
96.79	1.257	29.974	0.850	0.850	-0.484	-0.500	32.720	33.121
83.46	1.218	29.053	0.850	0.850	-0.484	-0.500	32.094	32.495
70.12	1.175	28.008	0.850	0.850	-0.484	-0.500	31.383	31.784
56.79	1.124	26.791	0.850	0.850	-0.484	-0.500	30.556	30.957
43.46	1.062	25.324	0.850	0.850	-0.484	-0.500	29.558	29.959
30.13	0.983	23.444	0.850	0.850	-0.384	-0.500	25.714	28.681
14.79	0.849	20.243	0.850	0.850	-0.500	-0.488	26.504	26.193
0.00	0.849	20.243	0.850	0.850	-0.500	-0.488	26.504	26.193

Figure 13. Structural Loads and Applied Forces.

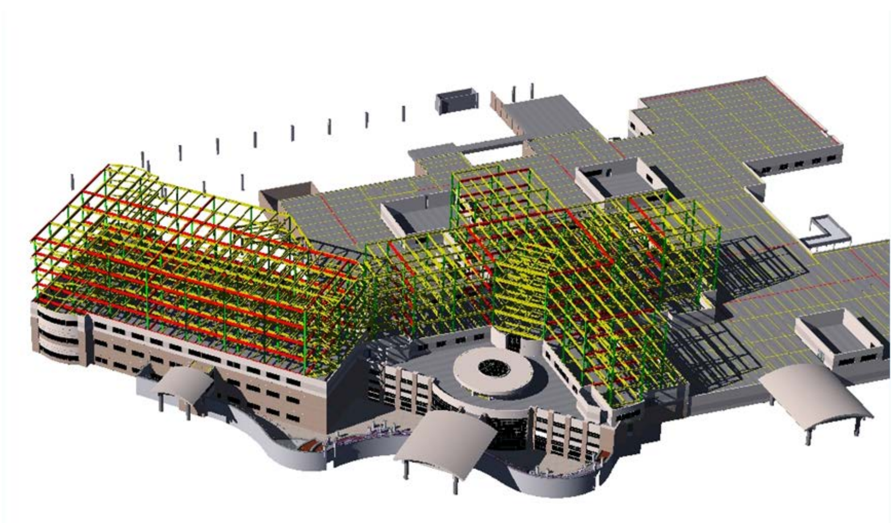


Figure 14. Steel Detailing.

- Bentley Structural Modeler: http://www.bentley.com/en-US/Products/Bentley+Structural
- RAM Structural System: http://www.bentley.com/en-US/Products/RAM+Structural+System
- STAAD Pro: http://www.bentley.com/en-US/Products/STAAD.Pro/

2.7 Mechanical, Electrical, and Plumbing Systems

Mechanical, electrical and plumbing systems require significant coordination between systems, due to the close proximity of buildings systems to each other. The use of BIM eases the coordination of these systems by identifying clashes between systems. Electrical design provides for lighting layout, switching and panel box loading (Figure 15). Quality of lighting can be analyzed with foot candle calculations. Mechanical systems layout supports the placement of ductwork and equipment (Figure 16). Plumbing design includes fire protection, potable/non-potable water piping, and sewer piping (Figure 17).

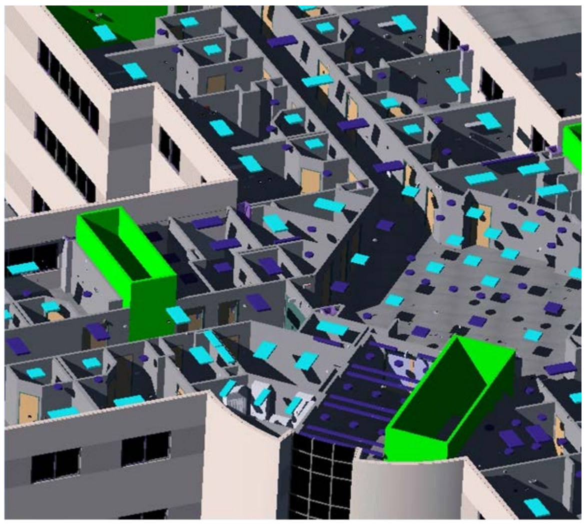


Figure 15. Electrical BIM.

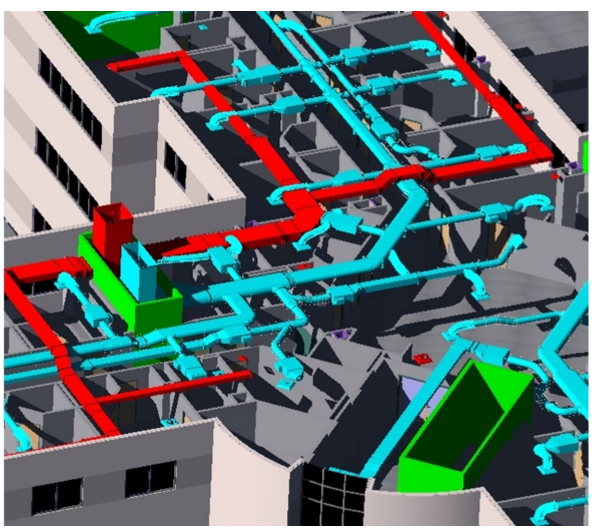


Figure 16. Mechanical BIM.

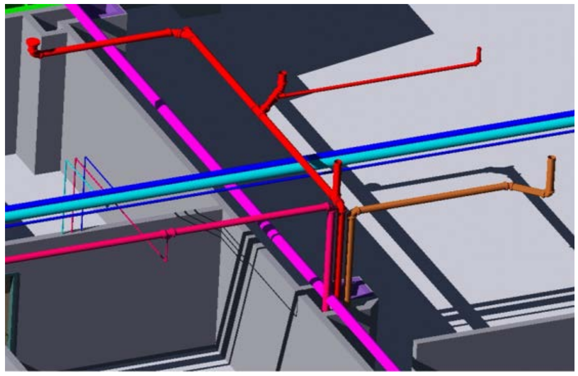


Figure 17. Plumbing BIM.

- Bentley Building Mechanical Systems: http://www.bentley.com/en-US/Products/Bentley+Building+Mechanical+Systems/
- Bentley Building Electrical Systems: http://www.bentley.com/en-US/Products/Bentley+Building+Electrical+Systems/

2.8 Energy Analysis

Equipment sizing and energy performance simulations are analysis tools that allow the design team to evaluate design alternatives that improve building energy performance. Visualization of air flow enhances the understanding to evaluate complex room conditions (Figure 18). Exterior building material selection (i.e., exterior cladding, sheathing, insulation, glass type) is required to perform an analysis of the building envelope (Figure 19). Building simulation allows the design team to evaluate building site orientations, building envelope alternatives, equipment performance and the effect space use and operations have on the performance of the building (Figure 20).

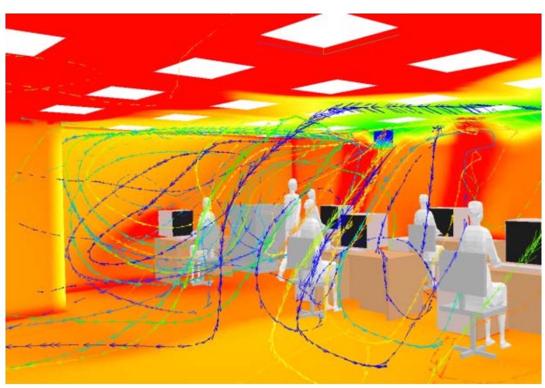


Figure 18. Air Flow Dynamics.

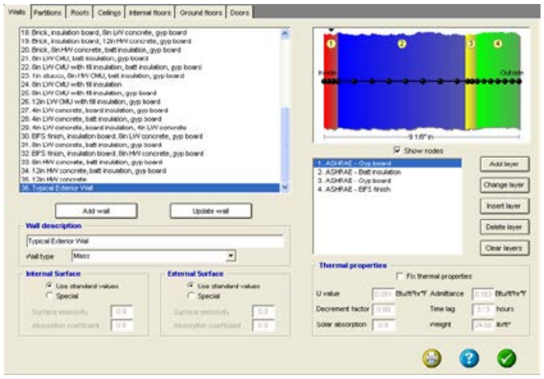


Figure 19. Construction Material Composition.

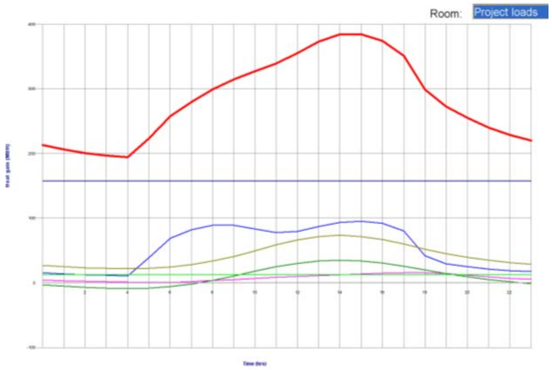


Figure 20. Heat Gain at Time of Day.

- Hevacomp Simulator: http://www.bentley.com/en-US/Products/Hevacomp+Dynamic+Simulation/
- Hevacomp Electrical Designer: http://www.bentley.com/en-US/Products/Hevacomp+Electrical+Designer/
- Hevacomp Mechanical Designer: http://www.bentley.com/en-US/Products/Hevacomp+Mechanical+Designer/

2.9 Facilities Management

BIM supports the entire building life cycle from design, construction and operations. Critical facilities data collected during design and construction can be imported into the owner's Computerized Maintenance Management Systems (CMMS) for facilities operations and maintenance. Facilities management focuses on space and asset management (Figure 21). Maintaining an up-to-date central repository of critical facility data ensures a single source of information for decision support and provides data to optimize facilities operations. The facilities data can be linked to other business systems for business analysis and reporting (Figure 22) including lease management, real property management, sustainment management, and maintenance and building operations.

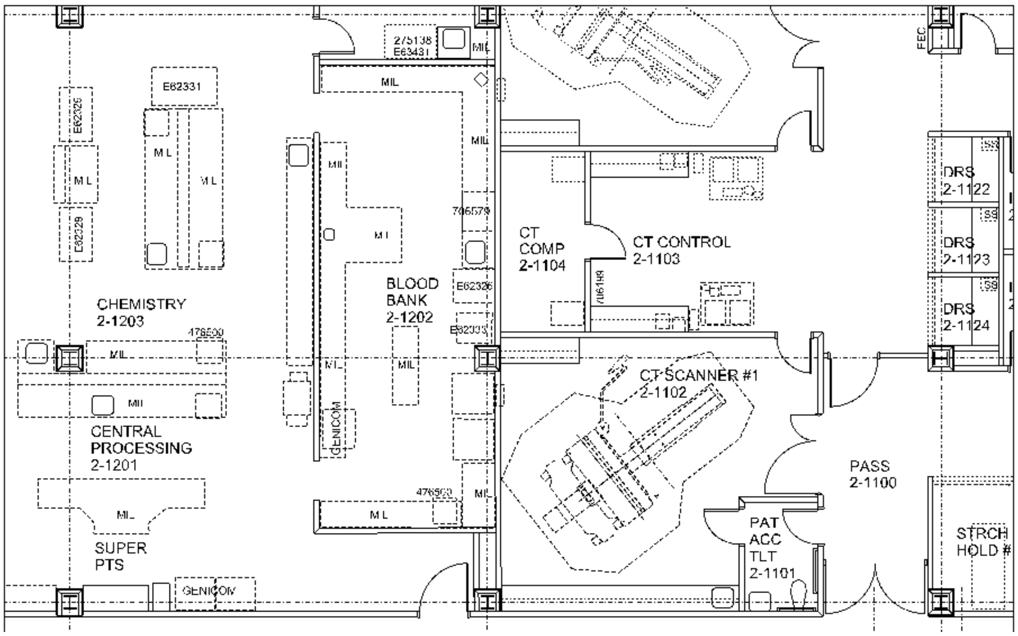


Figure 21. Facility Plan.

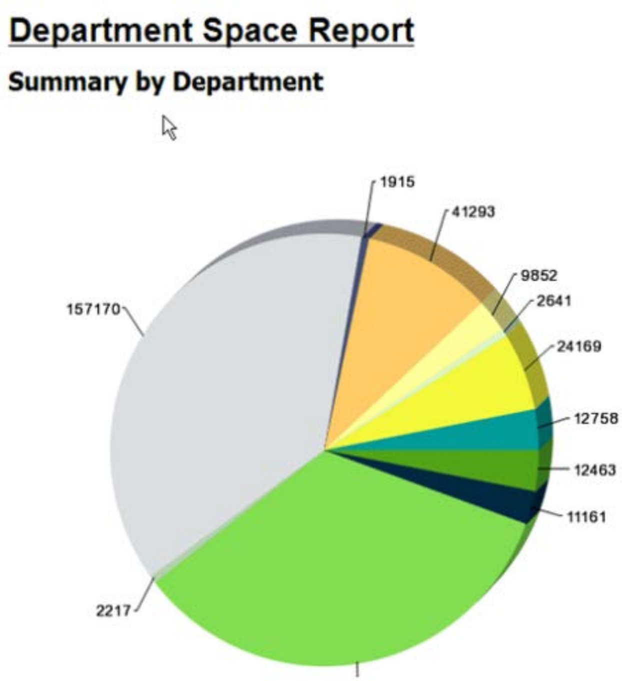


Figure 22. Space Report Summary Pie Chart.

- Bentley Facilities: http://www.bentley.com/en-US/Products/Bentley+Facilities/
- Bentley Facilities Planner: http://www.bentley.com/en-US/Products/Bentley+Facilities+Planner/

- Bentley Facilities Inquirer: http://www.bentley.com/en-US/Products/Bentley+Facilities+Inquirer/
- Bentley Facilities Manager: http://www.bentley.com/en-US/Products/Bentley+Facilities+Manager/
- Bentley Facilities Web Reports: http://www.bentley.com/en-US/Products/Bentley+Facilities+Reports/

2.10 Document Management and Drawing Production

A benefit of BIM is the efficient creation of 2D construction drawings (Figure 23 and Figure 24). From a multidisciplinary model, drawing views can be created ensuring that the drawings are up-to-date and well coordinated. The drawing views can be laid out as drawing sheets with annotations, dimensions and sheet-specific details added to complete the contract documents. The process of creating drawing views can be automated and managed with document management tracking the most current version and notifying other team members of updates. Plot production can be centralized with server-based plot creation, offloading the task from multiple client personal computers. Server-based plotting requires that a plot request be created. The plot request is basically a recipe of what is to be plotted. This request can be used each time the drawing is to be plotted thus ensuring the plot is consistent every time.

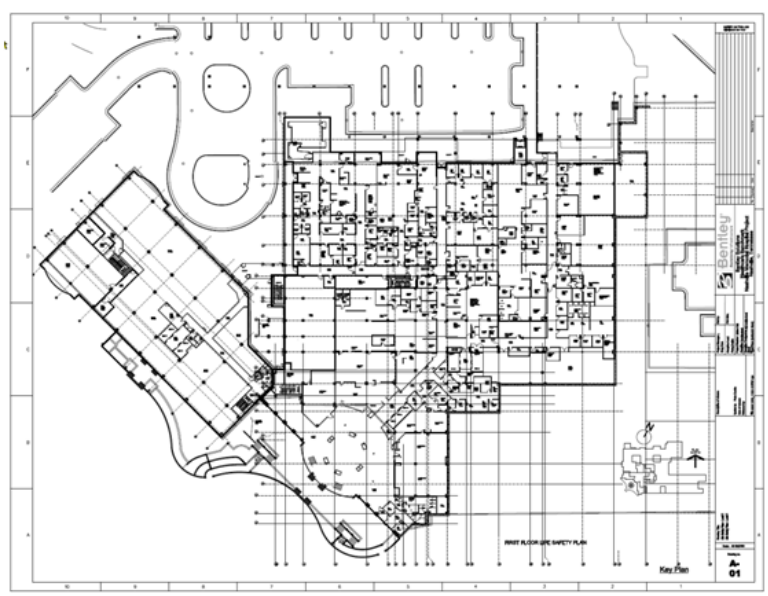


Figure 23. Floor Plan Construction Drawing.

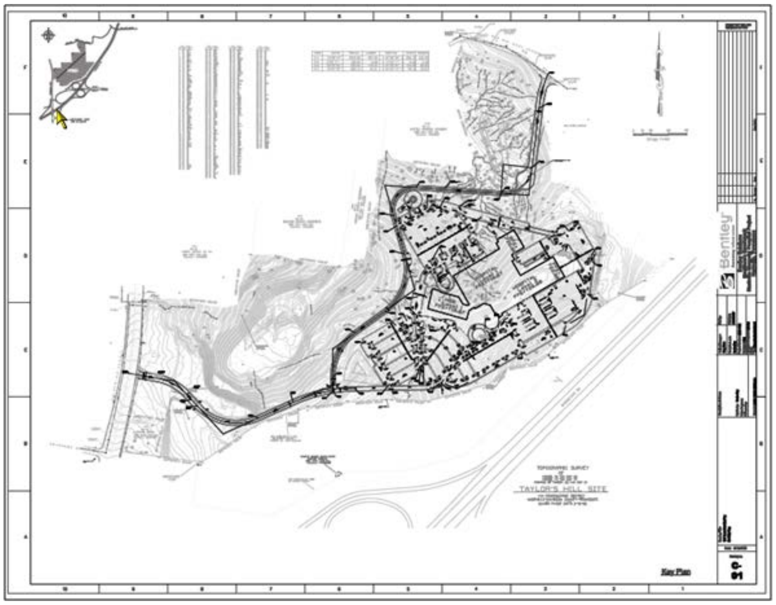


Figure 24. Site Plan Construction Drawing.

- ProjectWise Integration Server: http://www.bentley.com/en-US/Products/ProjectWise+Integration+Server/
- ProjectWise InterPlot: http://www.bentley.com/en-US/Products/ProjectWise+InterPlot/
- ProjectWise StartPoint: http://www.bentley.com/en-US/Products/ProjectWise+StartPoint/

2.11 Design Review

Design review is a process that monitors work-in-progress, assists with quality checks and promotes collaboration among project participants. The design review process involves the use of multiple document types including 3D models, paper drawings, and PDFs (Figure 25) to coordinate the design and contract documents. Design review includes coordination/clash detection between the building systems (i.e., architectural, structural, mechanical, electrical and plumbing) and managing resolution with the other disciplines (Figure 26). Schedule simulation (Figure 27) provides for evaluating the influence of time (i.e., 4D) on the design or construction process. Enhanced visualization for renderings and animations provides for review of both quality of space and material usage.

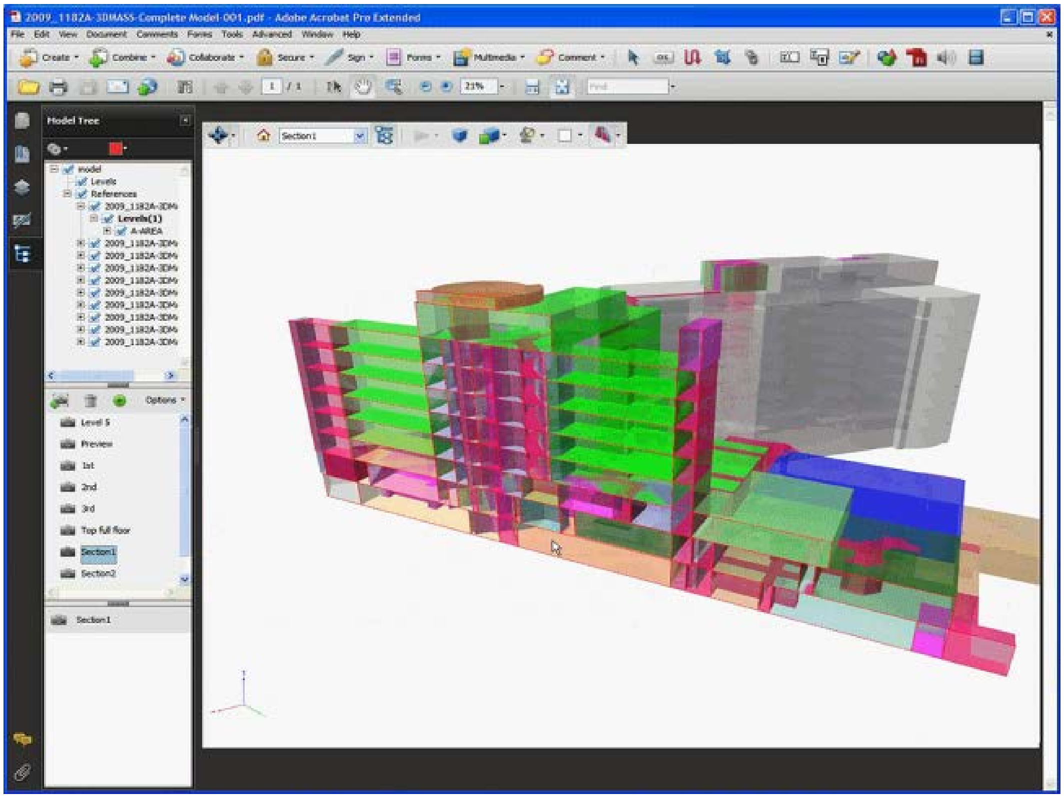


Figure 25. 3D Adobe PDF.

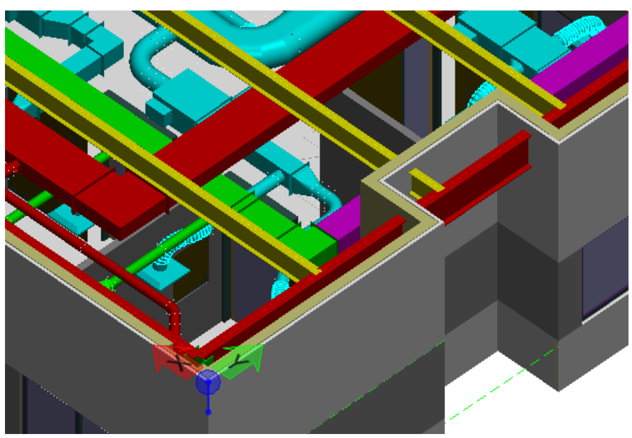


Figure 26. Multidiscipline Coordination.

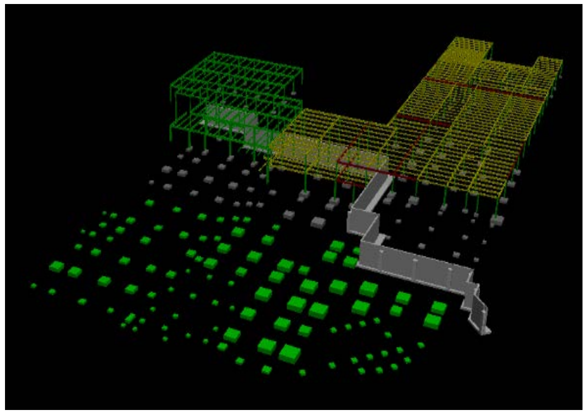


Figure 27. Schedule Simulation.

- ProjectWise Navigator: http://www.bentley.com/en-US/Products/ProjectWise+Navigator/
- Bentley Interference Manager: http://www.bentley.com/en-US/Products/Bentley+Interference+Manager/

2.12 Collaboration

The sharing of project information (i.e., program requirements, models, drawings, sketches and specifications) and coordination among a globally distributed project team (Figure 28) is critical to project success. The procurement methods of design-build and integrated project delivery highlight the requirement for data sharing. Collaboration and document management tools (Figure 29) help to make efficient communications and provides a single source of truth for all project information maximizing workforce utilization across multiple offices. Document management also saves time in finding, validating and accessing project information. With the definition of project workflow, security can be enabled to control document access, tasks can be automated and communications made efficient.

Figure 28. Example Globally Distributed Project Team.

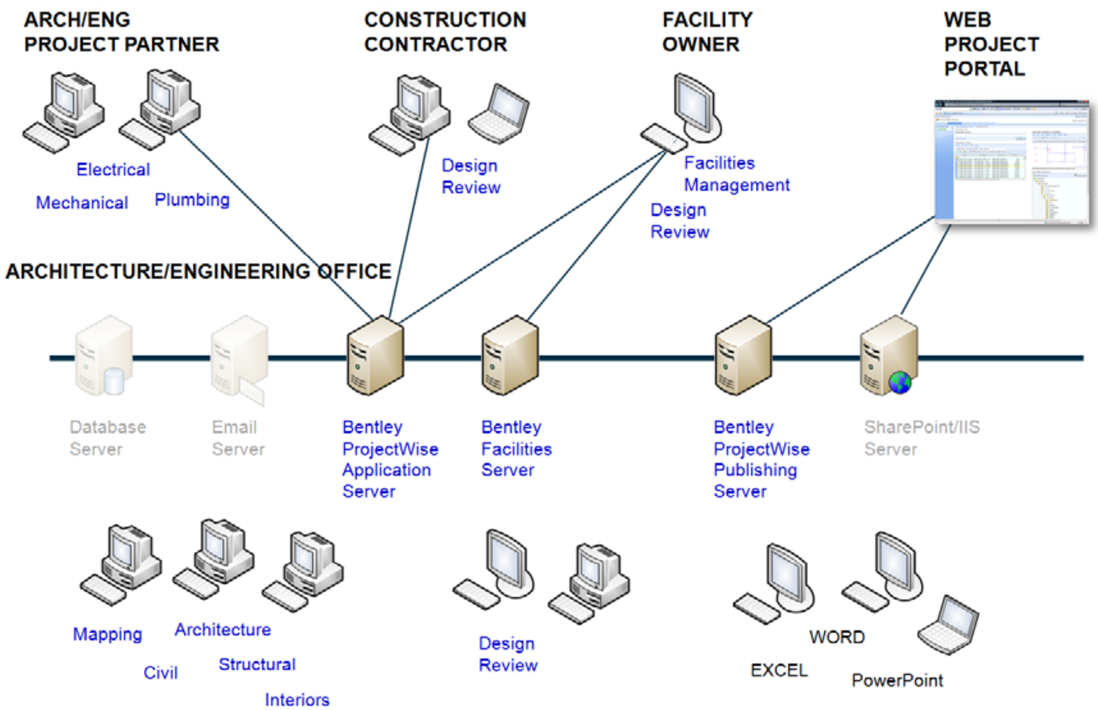


Figure 29. ProjectWise Collaboration Solution.

- ProjectWise Integration Server: http://www.bentley.com/en-US/Products/ProjectWise+Integration+Server/

3 Project Setup and Management

3.1 Scope of Work Defines BIM Requirements

Building Information Modeling provides opportunities and challenges in project delivery that is larger in scale than the paradigm shift that was experienced when engineers and architects moved from the drawing board to CAD. To address this challenge, Project Managers must grasp the new BIM process and key changes to current project delivery processes in order to set appropriate expectations for scope, schedule and budget. This section is designed to help the Project Manager and BIM Manager successfully deliver a USACE project using BIM.

The project scope of work (SOW) defines project goals and contract deliverables, including BIM data requirements. Since BIM drawing and data requirements define BIM modeling and input strategy, it is important that the Project Manager and the BIM Manager share the SOW and therefore, the BIM requirements with the entire project delivery team.

Below is a list of potential questions that the Project Manager and BIM Manager should consider when preparing a USACE MILCON BIM project:

1. Are we using the Tri-Services Workspace for BIM and CAD standards?
2. What level of collaboration is required; is the design team centrally located?
3. Which Center of Standardization (COS) dataset (if any) will be used?
4. What format does the owner/customer expect the deliverables in?
5. What software is required?
6. What training is required to ensure the team has the required skills?
7. Will the project process include the use of a BIM Pit?
8. What are the BIM deliverables for each project phase?
9. How will the BIM be reviewed with stakeholders during reviews sessions?
10. What are the project archiving requirements?
11. What specific building information needs to be captured and transferred for facility operations?

USACE BIM leadership has authored a Project Execution Plan (PxP) template. The template was developed by a team that has an understanding of the Bentley BIM process and is a guide to define uses for BIM on a project. The PXP template can be found at the link provided below.

- USACE Project Execution Plan: https://cadbim.usace.army.mil/BIM_Files/USACE_BIM_PXP_TEMPLATE_V1.0.pdf

3.2 Tri-Service Workspace for BIM and CAD Standards

Before the project begins, a BIM Manager must establish the workspace for the project. The workspace is a set of folders and software settings files that configure the BIM applications' interface and data structures. The USACE has defined and provided the Tri-Service Workspace for efficient project setup and to ensure consistency between projects. It supports the A/E/C CAD Standard and MILCON project workflow. The Tri-Service Workspace is available from the CAD/BIM Technology Center's website.

The BIM Manager is needed to deploy the Tri-Service Workspace. It includes "how to" instructions for installation, but there are really only two questions that must be answered when deploying it:

1. *Where does the corporate data reside?* The USACE corporate dataset contains BIM and CAD data for objects and output that are common among all USACE projects. It has been developed by architectural/engineering and USACE BIM teams to provide standards for data structure and output such as drawings and schedules. It should be used on all USACE BIM projects.
2. *Where does the project data reside?* The USACE project template holds all construction documents created during design development (e.g., 2D sheets, specifications, BIM clash detection reports). It also contains the project dataset which is the location for all project specific BIM data. The project template folder structure ultimately becomes the deliverable of the project.

- CAD/BIM Technology Center: https://cadbim.usace.army.mil/BIM

3.3 Levels of Collaboration

ProjectWise offers many levels of configuration for file management for BIM projects. Bentley's BIM products and the Tri-Service Workspace are integrated with ProjectWise and the USACE ProjectWise Collaboration

Model (PCM). (Note: whether ProjectWise is used or not, BIM projects are supported with the same corporate dataset).

If the project team has a requirement to maintain a unique non-shared corporate dataset then ProjectWise can be configured for a hybrid level of file management. All of the project files (i.e., models and drawings) created during the project will be stored in ProjectWise while the BIM application configurations and standards remain external to ProjectWise. This configuration is best used by a USACE District or AE BIM team that will do all of their work from one server location (i.e., all team members work in the same building). The BIM project can be packaged and delivered for submittals.

If complete virtual teaming is required and the corporate dataset is to be shared with all team members, then ProjectWise can be configured to manage all of the project files and the application configurations and standards. This is considered best practice for Project Delivery Teams who reside in multiple firms or locations. Bentley offers project web portals and other solutions for teams who need limited access to the project and do not require a full implementation of ProjectWise.

3.4 COS BIM Design Templates

USACE BIM Teams, working with AE design partners, have created Centers of Standardization (COS) datasets to be used as a starting point for BIM projects. These standard designs, which are maintained by each COS, are the focal point of the adapt-build process that USACE has embraced. Each COS dataset has a specific project dataset including intelligent objects developed in Bentley BIM. If a COS design is being executed, the appropriate COS dataset is to be used in place of the project template dataset delivered with the Tri-Service Workspace. Both AE and USACE BIM teams should request the COS dataset from the district assigned to maintain that facility type. The COS project datasets can be taken on-site for project meetings and design charettes.

Each COS BIM template should be updated each time a project of that type is completed, thereby improving the quality of the standard design. The quality assurance processes discussed in this section should be applied to discover modeling issues and improve the quality of COS BIM content. The required data mining activities are identical in nature to those required for quality assurance checking but the results are focused on design optimization versus identifying design discrepancies.

3.5 Acquiring and Installing the Right BIM Products

Identifying and acquiring the necessary software and making it available to all project team members is a critical step in project preparation. The project SOW and deliverables will define BIM requirements and the BIM applications needed for the project.

3.5.1 Subscriptions and Products

USACE BIM Managers, ACE-IT teams, and Bentley have worked together to provide USACE District design teams with the appropriate software products and versions that have the Army Net Worthiness certification. These products are supported by the Tri-Service Workspace. The Bentley BIM products are available for download at Bentley's SELECTservices: Downloads.

There are several methods for the project teams working on USACE projects to gain access to the required BIM software. These include Passport Subscriptions which are tailored to provide specific software products, training and content or the USACE Enterprise License Agreement (ELA) which provides USACE access to almost the entire Bentley portfolio of products. To facilitate training and coaching, the Enterprise License Agreement also includes training units which are managed by USACE Districts and USACE HQ.

- Bentley Support and Services: http://www.bentley.com/en-US/Services

3.5.2 BIM Product Versions

Each Tri-Service Workspace version is tested with a specific version of Bentley BIM products at the time the Tri-Service Workspace is released. The Tri-Service Workspace installation document lists the Bentley BIM product versions that have been tested for each Workspace. It is important that the tested and approved BIM products are installed for the project based on the selected Tri-Service Workspace. If the Tri-Service Workspace is not being utilized then refer to the Bentley SELECTservices support site to determine the most recent version of the products available.

- Bentley SELECTservices: http://selectservices.bentley.com/en-US/

3.5.3 Hardware Recommendations

Bentley realizes that managers and users need help in making decisions about what computer hardware to purchase in order to efficiently support the project using BIM. However, there are many software variables that can affect computer performance. The following recommendations are appropriate at the date of publishing of this document. Please contact a Bentley Technical Services representative to discuss the project's specific needs.

User desktop recommendation:

1. Operating System: Windows 7
2. System RAM: 4GB minimum, 8GB recommended
3. Discrete Graphics card with 512MB video RAM, and hardware support for DirectX 11
4. Dual or large monitor systems are best when developing 3D design models.

Server recommendations:

1. There are no additional server requirements for Bentley BIM products beyond those normally used in a CAD or ProjectWise server configuration.
2. Consideration should be given for the use of ProjectWise caching servers to optimize accessibility of project data among distributed offices.
3. It should be noted that delta file transfer between a ProjectWise server and the design desktop will optimize file transfer to the application user.

- SELECTsupport: http://selectservices.bentley.com/en-US/Support/Contact+Us/

3.6 BIM Team Training

Bentley BIM training is offered in a variety of ways (e.g., classroom, online, workshops, etc.) to optimize a training program that accommodates an organization's or individual's learning needs. The Project Manager and BIM Manager should assess the skills of the project team and make a recommendation for training either as a group or at an individual level.

3.6.1 BIM Implementation Workshop

For firms new to the BIM concepts; a two day workshop can help the team develop the needed understanding and provide guidance in the development of a viable and feasible BIM Implementation plan.

3.6.2 BIM Production Workshop

An efficient way for an organization to ramp-up in-house production quickly is to participate in a USACE sponsored BIM Workshop Program. This workshop program provides guidance and consulting on key process changes based on BIM technologies. It establishes guidance on the use of USACE BIM standards, workflows and data management practices while demonstrating the advantages of BIM and deployment of best practices in a project environment. The BIM Production Workshop is described in detail within the Training Section of this supplement.

3.6.3 BIM Managers Workshop

The BIM Manager is one of the most vital members of the project team. The BIM Manager advises the Project Manager and project team participants on such matters as project workflow, data management and the implementation of the USACE BIM standards and project workspace configuration controls. It is recommended that the BIM Manager attend a BIM Managers Workshop prior to a BIM Production Workshop or soon afterwards to exploit the ROI benefits offered by the introduction of new technologies and building information management processes. The BIM Managers Workshop is described in detail within the Training Section of this supplement.

3.7 The BIM Pit

The BIM Pit is a project design process concept which co-locates the entire project design team for a short period of time. It can elevate the level of collaboration and nurtures the development of a project scope for a successful BIM project and program.

The BIM Pit concept is widely used by USACE project teams and has been utilized successfully for the streamlined introduction of BIM technologies and the propagation of best practices. Many Engineer Districts have elected to maintain BIM Pit production areas that are used specifically for this function.

The Bentley federated file system empowers the BIM Pit by allowing for multiple designers to model and visualize their collaborative work in real time. BIM Pit collaboration provides more efficient design review and QA processes by enabling project team critique and optimization.

The BIM Pit is considered a best practice for BIM enabled design due to the extensive time savings and improved design coordination that has been realized since its introduction within the USACE in 2006. It is described in more detail in Appendix A: District Execution Framework in the USACE BIM Roadmap.

3.8 BIM Deliverables

By default, all BIM data and contract documents (i.e., models, drawings, and reports) created during the BIM process are stored within the project folder structure that is delivered with the Tri- Service Workspace. This folder structure and its contents are key BIM project deliverables for a USACE BIM project. The folder structure and its contents are typically delivered (in their entirety) during each project submittal. There are guidelines available for help with submittal requirements for most BIM projects such as the United States Army Reserves (USAR) Design Submittals Requirements (see links below).

The project deliverables from BIM should be defined early in the design process and updated throughout the life of the project. Information within the BIM environment begins with very basic data and input. As the design proceeds through the respective phases of a MILCON project, project data and improved workflow practices mature with greater detail being added continuously. The Bentley BIM products offer tools for the design team to continually enhance the BIM process, functionality and improved digital deliverables throughout the design process.

- Army Reserve Design Process & Submittal Requirements Part A: http://www.lrl.usace.army.mil/ed2/article.asp?id=169&MyCategory=212
- Army Reserve Design Process & Submittal Requirements Part B (Design Bid Build): http://www.lrl.usace.army.mil/ed2/article.asp?id=244&MyCategory=212
- Army Reserve Design Process & Submittal Requirements Part C (Design Build): http://www.lrl.usace.army.mil/ed2/article.asp?id=243&MyCategory=212

3.8.1 Data Development for Iterative Design

The Project Manager and BIM manager must consider the evolution of BIM data during the iterative design process in order to set expectations on BIM submittals. As an example of how data matures and is “re-purposed” throughout the life cycle of a project, consider the space/room layout.

> A space/room layout report, extracted from a COS Standard Design BIM, includes space usage, square footage, occupancy, and other data based on standard Army allowances. This report is very valuable during project initiation, for programming the DD 1391, and developing cost estimates. While the design and the respective model information contained within the BIM environment at this stage are at a very basic state, model output is accurate and thorough.
>
> During project planning and design phases, BIM data would typically be used during the planning charette to create conceptual plans, refine the DD 1391 submission and update cost estimates. The design team will use the same space definitions to begin wall placement, calculate initial mechanical sizing and support the tasks that are required for designing the functional layout of the building. As the space/room information is further developed, so is the reporting output. This BIM data evolves from space utilization reports into a complete room finish schedule and eventually becomes referenced into contract drawings and documents ready for bidding.
>
> During the project execution phase and after project award, the contractor will use the same file(s) to add data needed for the operations of the facility such as warranties and manufacturer specifications. Reports and data output are available in many formats (i.e., XML, Excel, ASCII text) to support data exchange needs of the local Department of Public Works (DPW) and occupying agency or site activity.

A significant amount of project data can be propagated forward about a building space or any other pertinent graphic or data object in BIM. The space/room example is a typical downstream data flow regarding pertinent building information. Other design processes typically discover their own set of exploitable workflows for the repurposing of BIM information such as a structural analytical model (created using STAAD.Pro or RAM) that is easily transitioned toward a physical model that is used to coordinate with the other building systems (i.e., mechanical, electrical and plumbing).

3.9 BIM Progress Review and Design Communications

A key goal of the BIM project implementation process is “to show progress often”. New BIM projects frequently get caught up with graphic modeling issues while the Project Manager and the key stakeholders want (and need) to see a broader view of how the BIM project is progressing. It has proven important to project success to hold team and client reviews in which the progress of the BIM is reviewed and communicated. This improves the general understanding of important project team design considerations and saves time in responding to project inquiries, questions, and addressing important customer comments or concerns.

Four simple ways to effectively present BIM progress include:

1. Utilize the Bentley BIM product functions that support model review/fly-thru capabilities that are similar to ProjectWise Navigator. These tools are embedded within the BIM products for continual use during the design process. This is one of the best ways to show progress of the production design team (real time).
2. Publishing and distributing a 3D PDF document plot of the model for review directly from the Bentley BIM is the second way. This is the best tool to create a “snapshot” of the geometric design that may be easily distributed to all interested reviewers via email.
3. This 3D PDF file can be easily reviewed, rotated and “flown thru” by all users. Figure 30 demonstrates the Child Development Center BIM designed by USACE Huntsville Engineering and Support Center. Double click on the embedded Adobe Acrobat Icon to review the architectural design.

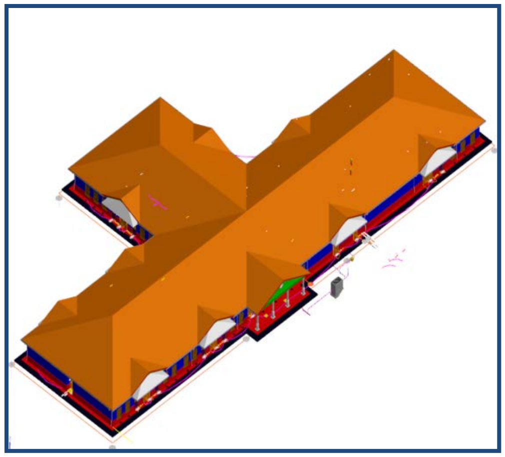


Figure 30. Adobe 3D PDF output.

4. The BIM to PDF Pilot Project is another success story which demonstrates a means for distribution of installation information in an accessible, simple to navigate format.
5. ProjectWise Navigator and *i*-model technology provide an easy to use project review tool-kit for project managers and other project stakeholders. These software tools enable the in-progress review process to be affordably expanded with “content rich” views of model and design data. The Tri-Service BIM workflow defines a project master model from which to publish a comprehensive *i*-model and ProjectWise Navigator is used for redline markup and commenting.
6. ProjectWise Navigator is also typically used for construction schedule simulations and animations that can facilitate more comprehensive design, estimating and construction management discussions. For example, real-time fly through sessions with larger groups often saves valuable time by expediting design coordination discussions.

It is critical that the Project Manager integrate BIM into the design review process at key project milestones to ensure design intent and model integrity. During the Internal Technical Review (ITR) phase and throughout the design process, architects and engineers will review and continuously evaluate the structural considerations and analysis, systems coordination, building performance and space functionality of the proposed building design.

- BIM to PDF Users Guide: Creating a BIM Project Portfolio: https://cadbim.usace.army.mil/MyFiles/1/3/3/BIM%20to%20PDF%20Users%20Guide%20v1.pdf

3.9.1 Visual Design Review

The quality assurance process for BIM includes visual design review. This process includes navigating through the model, in a fly-thru mode, and validating the location of building components.

The BIM shown in Figure 31 accurately represents the designer's intent, including Civil/Site and Architectural features. It is directly output from the Raleigh Durham Army Reserve Training Center in Raleigh Durham, NC.

Figure 31. Rendering Output of Bentley BIM.

ProjectWise Navigator provides several modes for moving through a model, creating renderings and animations. Working with an *i*-model, ProjectWise Navigator creates an "intelligent snapshot" of the design by providing the geometry and business data for review. To distribute the BIM to a broad audience who may have access to the BIM production applications, a 3D PDF plot of the BIM can be created to provide a "snapshot" of the design.

Visual design review tasks include:

1. Navigating or flying-thru the BIM environment to review the coordination between all disciplines and to identify any uncoordinated design issues.
2. Querying and reporting on BIM objects to inspect for required graphical representations and business data. Individual or groups of building object(s) may be queried and reported on. Queries allow for filtering of BIM objects to isolate specific disciplines, floors or areas of interest.

3.9.2 Clash Detection

Clash detection is a design review process for identifying, inspecting and reporting building systems interferences in a 3D model.

ProjectWise Navigator provides tools to identify, markup and manage resolutions to interferences from multiple file formats. The interference engine is available in desktop design applications so that during the design process a designer can check his/her work with other disciplines during design thus conducting a first level quality assurance review. Figure 32 displays a clash between the Mechanical and Structural designs on the Ft. Drum General Purpose Warehouse designed by USACE, Louisville District.

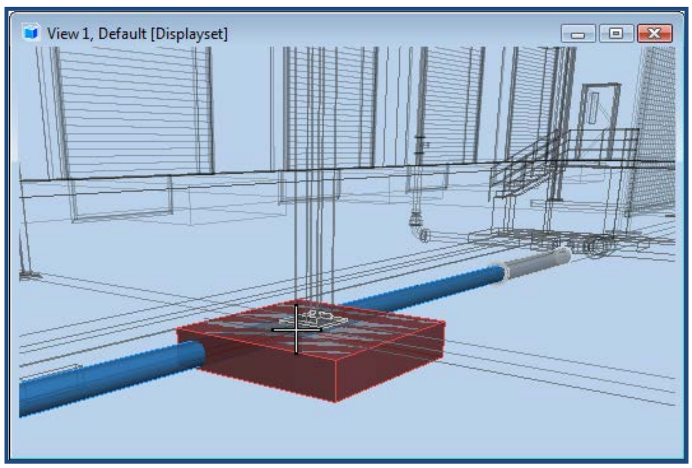


Figure 32. Clash Detection in Bentley Navigator.

Clash detection tasks include:

1. Designer clash detection is performed using the interference engine in the design application to compare a designer's specific work with other disciplines.
2. Design team clash detection is the process during which the design team representing all disciplines (i.e., civil, structural, architectural, mechanical, electrical, plumbing, etc.) compares their work in a master model to identify coordination issues.
3. Project clash detection is a design review process that includes BIM data from many design sources. The BIM data is not necessarily from the same BIM authoring platform. BIM data might be included from an IFC, Revit or other BIM authoring application.

3.9.3 Design Review Markups

During design review, discipline coordination and construction issues will be indentified and resolutions determined. This requires documenting the issues and communicating them to other team members. ProjectWise Navigator provides tools for capturing an image of a design issue and marking it up with comments.

Figure 33 demonstrates these tools on the Special Operations Facility BIM project completed by the USACE Middle East District. The markup tools within ProjectWise Navigator can be used to coordinate DrChecks[SM] comment numbers with very specific locations within the 3D space. An audit trail of the actions taken can assist the project manager to track and resolve issues identified. Using ProjectWise, the markups are stored in one location making them available to the entire project team.

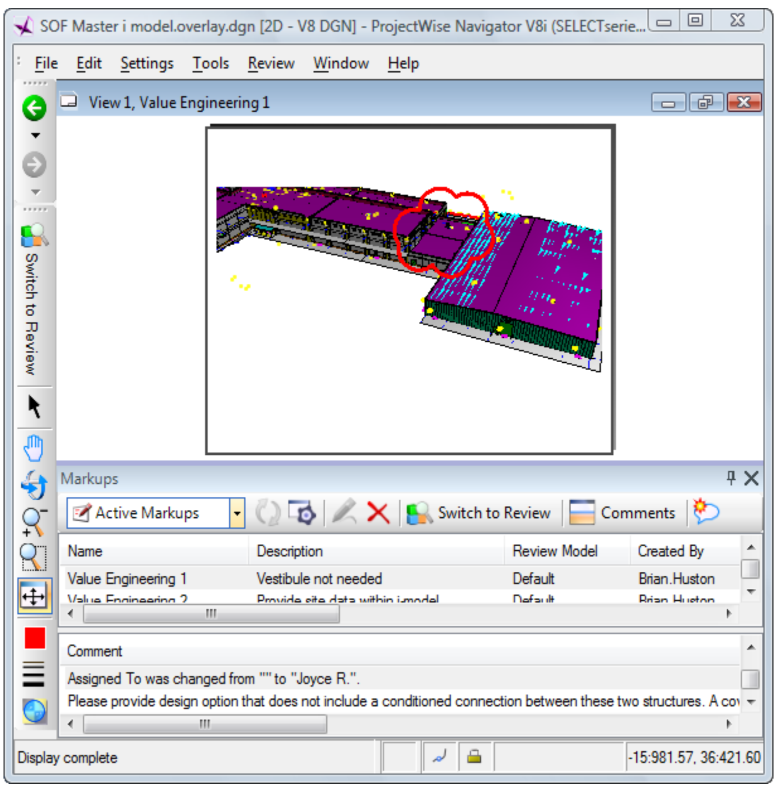


Figure 33. Design Review Comment Resolution in BIM

Markup design review tasks include:

1. Capturing a snapshot image of the design issues.

2. Marking up the snap shot with comments to clarify the problem or to suggest a resolution.
3. Linking the snap shot to the source of the design issue for review and resolution.
4. Distribute, track and verify comments across the entire project.

3.9.4 Verify Parts and Datagroup Validation

Managing and ensuring technical integrity of the BIM requires the validation of both the parts that the BIM is constructed from and the business data schema. There are tools provided in the BIM products to validate that the information is properly constructed within the delivered BIM.

Figure 34, taken from the USACE BIM Manager's Workshop at the USACE ERDC-ITL shows a typical part and family review.

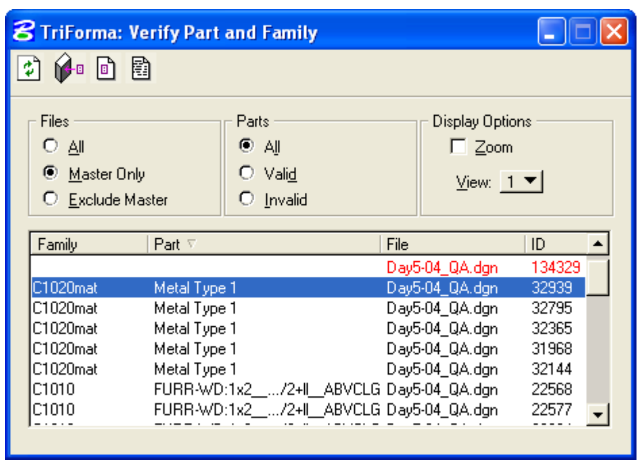


Figure 34. The Verify Parts Tool.

Tasks for validating the technical integrity of the BIM include:

1. Using the Verify Parts tool to check that the parts used in the BIM are accounted for in the dataset.
2. Using the Verify Parts tool to check that all elements are assigned parts.
3. Using the Datagroup Validation tool to check that the datagroup information is properly connected to the objects.

3.9.5 Design History

Design History is a valuable quality control tool for the objects within a BIM. Design History records changes made within the file and allows the designer to restore earlier revisions at an object level of management. When one creates a revision, the Design History tool captures the state of the DGN file at that moment, but allows for continued changes within the file. As design direction changes, some or all objects can be restored to earlier states if needed. Throughout the iterative design process, it is probable that many individuals will contribute to a BIM file. Design History functionally allows an engineer to review changes made since their last direct involvement, establishing confidence and trust in the model.

There are specific modeling steps that should utilize MicroStation Design History to provide a state of approval of design within the BIM. For example, a structural engineer who has completed the design within STAAD.Pro and is ready to import it into the BIM should turn on Design History. This provides a milestone within the model that the structural engineer may use to ensure that changes to the file after the milestone do not affect the structural integrity of the design.

Tools in the design history toolbox include:

1. Record changes in design history.
2. Restore elements from design history.
3. Show design history.

3.9.6 Standards Checker

The Standards Checker is a tool to compare graphic information in the DGN file against standards that have been established. It is a CAD-based tool that is available within the Bentley BIM products and configured for the USACE Tri-Service Workspace. The tool provides quality checking for CAD graphics including levels, text styles, dimension styles and line styles.

The Tri-Service Workspace pre-configures the Standards Checker to verify that USACE BIM deliverables comply with the A/E/C CAD Standard. The output shown in Figure 35 is a check of a Child Development Center designed by the USACE Huntsville Engineering and Support Center BIM team.

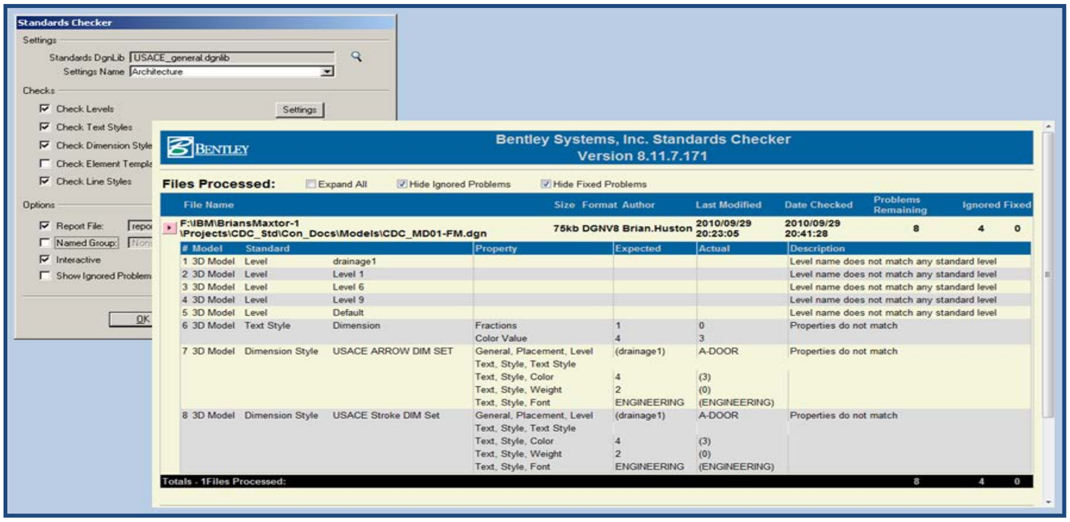


Figure 35. Standards Checker Utility and Output.

Tasks for checking CAD standards with Standards Checker:

1. Open a BIM project file (batch mode is available) Standards Checker within the Tri-Service Workspace.
2. Launch Standards Checker from the Utilities Menu pull down.
3. Determine output requirements and process.

3.9.7 Schedule Simulation

Project management tools such as Microsoft Project and Primavera P6 provide tools for defining work breakdown structures and time duration for tasks. The resulting comprehensive charts are often difficult to understand without extensive study. ProjectWise Navigator's schedule simulation tool enables one to visualize design options or construction sequencing by integrating BIM data with a project schedule. It is designed to help in the planning stages of a project so that engineers can get a visual representation of a sequence of required tasks. A movie can be created from the proposed BIM with a linked schedule providing an easy to understand visual image for non-technical project participants.

ProjectWise Navigator includes the tools to develop schedule simulations and either link them to existing project management plans or develop the schedule at the time. Figure 36 shows the Animation Producer within ProjectWise Navigator which is the central tool for schedule simulation.

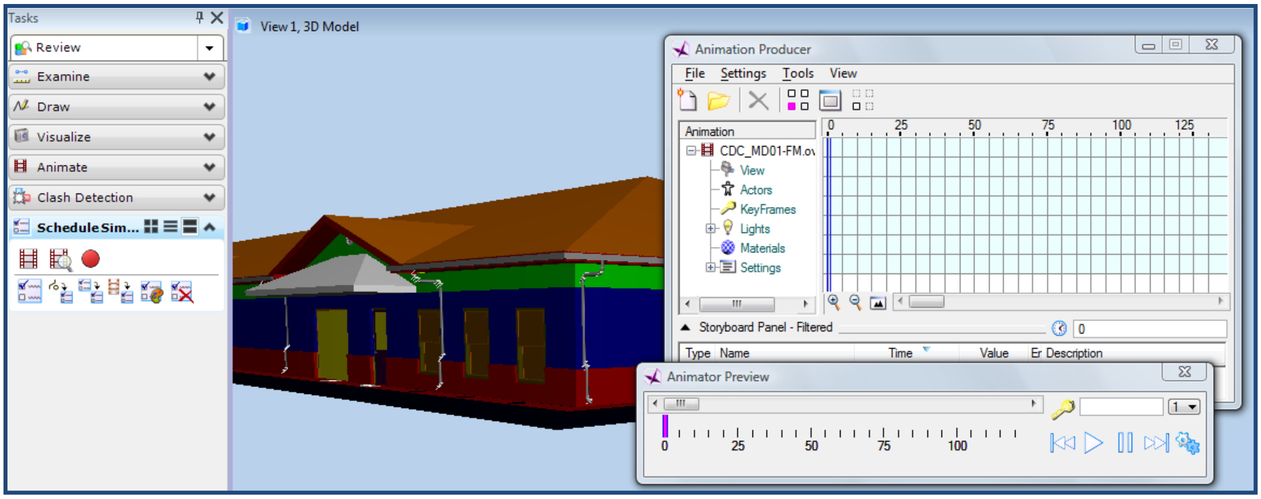


Figure 36. Bentley ProjectWise Navigator Schedule Simulation Tools.

The process for Schedule Simulation:

1. Import a schedule or create a schedule.
2. (Optional) Modify the tasks in the schedule.
3. Attach elements or named groups to tasks in the schedule.
4. (Optional) Modify scripts attached to tasks.
5. Preview the schedule simulation.
6. (Optional) Export a schedule.

3.10 Archiving Projects

The archiving of project data is triggered by events such as significant changes in design direction, the submittal of contract documents or District archive policy. The archiving process must include the archiving of all files required to reconstruct the project at a future date and make use of data during downstream project phases. This would include the BIM files, the project dataset files and version of the USACE Tri-Service Workspace.

The Tri-Service Workspace is uniquely configured to work at all phases of the life cycle of a BIM project. Packaging of the BIM for archiving is a straightforward process which is identical to the steps required for preparing a BIM project for submittal.

Tasks for archiving Tri-Service BIM project:

1. Package project folder including all files under the “con_docs” folder.

2. Annotate the Tri-Service Workspace version with archiving documentation.
3. Store data in accordance with district archiving policy.

3.11 BIM for the Facility Life Cycle

USACE is in the business of supporting our military installations by handing over quality designs and facility data for use during the life of the facility. It is therefore important that the BIM process develop and capture relevant facilities data for long term ownership, operations, and asset management.

Bentley Map allows master planners and programmers to view multiple data sources simultaneously while providing full MicroStation functionality. GIS, BIM and Civil integration allows for information to be evaluated in relationship to all relevant site and project data including utilities, drainage, and building orientation. Figure 37 displays a DGN file that references, ESRI data, multiple BIMs, raster imagery, and an InRoads Digital Terrain Model (DTM). All data is referenced and editable.

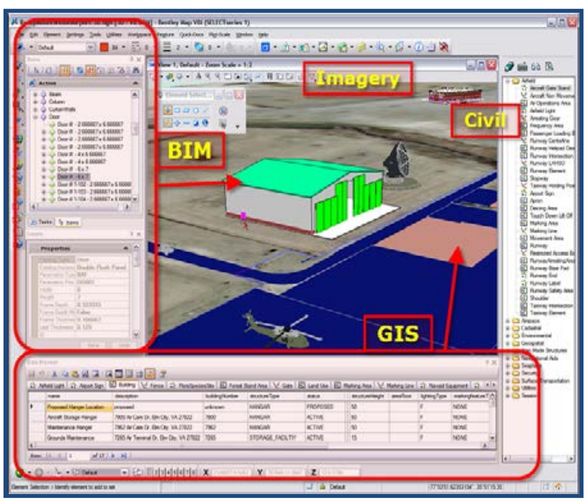


Figure 37. BIM/Civil/GIS Integration.

Bentley actively supports USACE design teams in developing data schema that supports the operations and maintenance (O&M) requirements of the USACE client.

Figure 38 shows output from the Bentley BIM to a Construction, Operations, Building information exchange (COBie) spreadsheet. The COBie standard is based on the Industry Foundation Class (IFC) data standards which is another output of the Bentley BIM. Additional information on Bentley's support of IFCs and COBie is available in the Interoperability Platform section below.

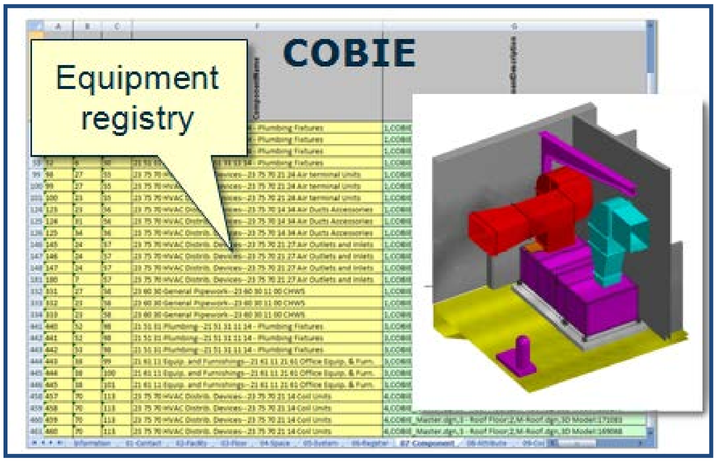


Figure 38. COBie export of Bentley Building Mechanical Systems.

It is important for BIM teams to clearly understand the project requirements for downstream use of design data. For example, a project site that wishes to utilize the BIM data within Maximo or other maintenance management system will most certainly need an asset identification number data field created on all relevant equipment. This is easily set-up within the Bentley BIM environment.

Bentley BIM products provide the flexibility to adjust the data that is being created and reported on for specific user requirements. This might include but is not limited to:

1. Space management
2. Asset management
3. IT infrastructure management
4. Operations and maintenance
5. As-built facility conditions
6. Simulated performance
7. Facility handover.

To reap additional benefits from the investment of collecting data during design and construction Bentley BIM products support many file formats for repurposing the data into other owner business applications. These file formats include but are not limited to the following:

1. XML
2. IFC
3. ASCII text
4. Microsoft Excel
5. URL address

3.12 BIM Project Management Checklist

Use the checklist below (Figure 39) as a reminder of tasks to complete or discussions to have with the project team.

✓		Tasks	Notes
	1	Define and communicate BIM scope (i.e., uses of BIM, what to model, level of detail) of work to team based on contract deliverables	
	2	Define BIM deliverables (i.e., model, drawings, reports, schedules, quantities) and review with team	
	3	Define data schema for BIM (i.e., business attributes) work with BIM Manager to configure project schema	
	4	Review BIM standards (i.e., libraries, modeling techniques, folder structures) and CAD standards (i.e. drafting line weights, style) with team	
	5	Work with BIM Manager to define ProjectWise level of collaboration (i.e., management of corporate and project datasets)	
	6	Review project schedule and identify participants and date(s) for BIM pit(s)	
	7	Review team skills and identify training requirements and schedule training	
	8	Define when and process for archiving project data	
	9	Review and confirm that hardware will meet needs for BIM	
	10	Acquire and install required BIM software products including those used for engineering analysis and building performance	
	11	Install Tri-Services Workspace	
	12	Acquire and install required COS dataset	
	13	Define use of MicroStation standards checker utilizing the Tri-Services Workspace for quality assurance	
	14	Define quality assurance process and reports for validating BIM by verifying parts and datagroup	

✓		Tasks	Notes
	15	Define use of design history for BIM management and quality control	
	16	Identify use of ProjectWise Navigator for visual design reviews and markups	
	17	Identify use of ProjectWise Navigator for multidisciplinary clash detection reviews	
	18	Identify use of ProjectWise Navigator for design and construction schedule simulation	
	19	Identify GIS data sources and connectivity avenues for engineers	

Figure 39. Bentley Project Management Checklist.

3.13 BIM Project Application Checklist

Use this checklist (Figure 40) to indicate which modeling applications will be used on MILCON projects and note the intended use in the project.

✓	Information Model Applications	Intended Use
	Map	
	Water	
	gINT	
	Gas	
	Electric	
	Fiber	
	GEOPAK Civil Engineering Suite	
	InRoads Suite	
	Architecture	
	Generative Components	
	Structural Modeler	
	RAM Structural Systems	
	STAAD.Pro	
	Building Electrical Systems	
	Building Mechanical Systems	
	Hevacomp Simulator	
	Hevacomp Electrical Designer	
	Hevacomp Mechanical Designer	
	Facilities	
	ProjectWise Integration Server	
	ProjectWise Interplot	
	ProjectWise StartPoint	
	ProjectWise Navigator	
	Clash Detection / Interference Manager	

Figure 40. Project Application Checklist.

4 General Project Guidelines

The guidelines outlined in this section were compiled from the many training sessions, workshops, and project coaching provided to the USACE.

4.1 Project Management

4.1.1 Select the Right Project

1. Pick a project that will improve project delivery workflow processes, advance the team's skills and minimize risk for the project.
2. Projects that benefit most from BIM technologies and processes share these characteristics:
   a. challenging design problems
   b. space constraints
   c. complicated engineering components
   d. multidisciplinary project team
   e. need to repurpose data (e.g., multiple buildings of same type, long-term operations).

4.1.2 Define Project Goals

1. Clearly define and communicate the use of BIM to achieve the contract requirements and stick to it (i.e., avoid SOW creep!).
2. BIM is not just a 3D model - the focus should be on process improvement, design optimization, reuse of critical facility data and efficient team collaboration.
3. Use BIM to make visible design challenges early in the design process and motivate collaboration among team members.
4. Read and understand the requirements of USACE Attachment F "Building Information Modeling Requirements" and the Project Execution Plan (PxP).

4.1.3 Understand BIM as a Process

1. BIM is both a process (verb) and product deliverable (noun).
2. BIM as a process requires the rethinking of the project delivery workflow and there is no "easy button". It requires all project stakeholders to contribute to the process improvement steps.

3. Document and communicate BIM process workflows to make BIM success repeatable. It is important for Project Managers and others entering into the BIM process to understand the process and manage expectations.
4. Define a plan for implementing BIM, monitor the progress and be flexible to try different alternatives.
5. One cannot force the 2D graphic based processes to the 3D data rich environment and expect significant improvements. The 2D graphics are the result of the 3D data rich environment.
6. Use BIM to move design decisions and collaboration forward in the project timeline resulting in greater influence to save time and project costs.
7. Keep all disciplines at a similar level of model development to leverage coordination and collaboration between building systems. The process becomes less beneficial if one or more disciplines fall behind.
8. Define early the requirements for model detail (i.e., granularity) and monitor the work to ensure time is not wasted due to over/under modeling the project.
9. The process will only be improved if feedback is provided to the USACE about what worked and what did not.

4.1.4 Create a Project Team Environment

1. Use BIM to enable a teaming environment for collaboration.
2. Strategically use the BIM Pit for rapid project development.
3. A virtual BIM Pit is feasible when supported with real-time chat, voice and visual communications.
4. Partner with the USACE District project owner and/or receiving agency. Each contracting District can have different expectations when it comes to the BIM deliverables. Do not assume that what one did for one District will be acceptable for the next District.
5. Standup and test the project workspace before users begin modeling because downtime is detrimental to the momentum of a project.

4.2 People Management

4.2.1 Build a Team

1. Seek out a person in upper management that will support the project goals and facilitate the process at a management level. They must sup-

port the vision for taking full advantage of BIM and have authority to make decisions regarding company-wide BIM efforts.
2. Select the professional staff to work in the BIM and do not return to the old paradigm of designers instructing drafters with redline markups. The professional staff is better positioned to take advantage of the many aspects of BIM to advance design decisions and the project.
3. Seed the first BIM project team with power users so that they can mentor other less experienced staff.
4. Training is essential for new BIM teams. Training as a team establishes esprit-de-corp.
5. All team members should be involved in BIM model and process review meetings to advance their BIM skills.
6. Continually evaluate the skills of those that have been trained to ensure the retention of skills and the development of new skills.
7. Manage the reactions to change. Some team members will embrace the BIM process; others will deny, and possibly a few will reject.

4.3 Design Management

4.3.1 BIM Workflow

1. Model the large building components first that require coordination with other disciplines to begin the process of space reservation before exploring component details.
2. Prioritize the modeling of building components that other disciplines must coordinate with to keep advancing the design.
3. Do not duplicate model components, coordinate with the discipline owner (i.e., architect creates and owns the ceiling grid; the electrical engineer places lights in that grid).
4. Model space required for serviceability of equipment (e.g., doors swings, electrical panel access, filters pulls, coils on mechanical equipment).

4.3.2 Reduce, Reuse, Recycle

1. Take advantage of modular design for quality control and production efficiencies (e.g., equipment layout, typical office layout).
2. Reuse data to save time from data re-entry. This includes both graphic and business data.
3. Standardize data for use on future projects.

4.3.3 Quality Assurance

1. Start the quality assurance (QA) process early in the project and repeat often because it can be overwhelming if left to the end.
2. The quality assurance process should evaluate the BIM from multiple perspectives including graphics, business data and discipline coordination.

5 Training Availability

USACE has worked with Bentley to develop training options that are designed to provide technical consulting support to the broad range that USACE needs. Bentley Training options are provided to support a variety of architectural, engineering, geospatial and content management requirements by focusing on the production, collaboration and workflow requirements of the USACE professional community.

BIM Production and BIM Management Workshops have been developed to help USACE project teams efficiently acquire skills for BIM business transformation, technology, and project implementations. The BIM workshop suite supports the development of diversified skills, including team collaboration training, project coaching, and professional consulting for the execution of USACE MILCON projects.

The USACE-sponsored BIM Workshop Program provides a cost effective, production-oriented training environment that produces immediate and measurable results. It has been tailored for USACE Project Teams that want to use BIM technologies for building design, analysis and construction management.

Bentley recommends that BIM Workshop training and project coaching begin as early in the design phase as possible to optimize short-term return on investment and long-term building data management results. Early adoption allows for improved project life-cycle scope definition in which BIM technologies and documented best practices can be more easily adapted to improve the workflow of the project team and to advance the MILCON business transformation goals of the USACE.

5.1 BIM Production Workshop

The BIM Production Workshop is a structured program that is available to quickly ramp-up a USACE project team with a collaborative approach that introduces facilitated workflow processes for improved building design, analysis, and design constructability. The BIM workshop program addresses all aspects of the modeling environment and is intended to improve project team dynamics, increase design team production and advise on workflow processes to successfully employ Bentley's BIM technologies for USACE MILCON projects. The key BIM workshop topics are outlined herein. These topics are based on project experience and documentation of best practices, but can be customized to the USACE District's needs.

- **Application Training** is provided on Bentley's Building products. It includes prerequisite training to orient the user to 3D modeling principles.
- **Project Startup Coaching** immediately follows the application training to capitalize on the skills developed in the first week. The coaching and consultation provided is "over the shoulder" and typically involves working on a funded and pre-selected MILCON project. Working on a real project with known project deliverables and requirements motivates project participants, and minimizes the cost of the training by permitting the BIM team to productively work on the project while developing BIM skills. This start-up week introduces USACE BIM standards, configuration management controls and best practices to the team and, typically, includes the phased introduction of the BIM Pit design environment.
- **Project Coaching** continues with over-the-shoulder coaching with an increased focus on project deliverables. Advanced topics are introduced to the entire team as well as discipline-specific training. BIM Manager training is also included on more complex topics such as BIM workspace configuration, BIM dataset management and BIM output techniques.
- **Project Submittal Coaching** is scheduled to support the team for project deadline submittals. This week of coaching is intended to ensure that the team is getting acceptable output from the BIM environment. Topics such as drawing extraction and sheet setup are covered and based on USACE BIM standards. More advanced topics are introduced that address project deliverables that are typically required for the completion of design process.

5.2 BIM Managers Workshops

BIM Managers Workshops provide BIM administrator level training on Bentley BIM and integrated content management solutions that propagate the utilization of USACE BIM Standards and the USACE Tri-Service Workspace. The Bentley Government Center of Excellence works with the USACE ERDC CAD/BIM Technology Center in Vicksburg, MS, to provide BIM Managers Workshops on an as-required basis (typically 1-2 per year). Additionally, Bentley offers an Advanced BIM Managers Workshop for the more advanced BIM production and system management needs of the USACE community.

The BIM Managers Workshop covers the following topics:

1. BIM implementation overview
2. The role of the BIM Manager
3. Installation, use, and trouble shooting of the USACE Tri-Services Workspace configuration
4. Application specific configuration and best practice tips
5. Data mining of completed design projects for improvements to standard and local datasets
6. Quality assurance procedures for a BIM design
7. Best practices for many processes
8. The USACE BIM Standards and workflows
9. New technologies that will affect the USACE business processes.

For information on selecting the appropriate managers training for a USACE BIM project, contact the ERDC CAD/BIM Technology Center. Navigate to contact information at https://cadbim.usace.army.mil/%5C.

5.3 Campus Information Management Workshop

Owner operators' business requirements include maintenance management, asset management, operational readiness, disaster recovery, and installation security. The Campus Information Management Workshop (CIM Workshop) explores the exchange and repurposing of data between planning, real estate and capital improvement to support these business requirements.

The CIM Workshop provides a process-centric approach for real world simulation exercises and review of planned capital projects for campuses or installations. This workshop reviews the cascading impact that large capital projects typically have on the process for planning, building design, civil engineering, capacity analysis of utility systems, encroachment and land acquisition. The CIM Workshop provides a hands-on experience on how to use the Bentley ProjectWise/Geospatial Server environment as a repository of engineering and GIS data.

The CIM Workshop (see Figure 41) examines multiple sources of facilities information and address the interoperability issues associated with the following multi-discipline processes and infrastructure/GIS data concerns:

1. Buildings, structures, and power generation and process facilities
2. Complex utility infrastructure (water, sewer, gas, electric, communication networks)
3. Transportation infrastructure (parking, roads, bridges, light rail, runways, etc.)
4. GIS, mapping and imaging data integration with legacy CAD information and more advanced information modeling such as BIM
5. Operational readiness and security
6. Infrastructure data and/or GIS feature links to operations and maintenance systems such as CAFM, CMMS, Real Property DB(s), etc.
7. Capacity planning and analysis
8. Time to market (optimize planning, programming, design, construction)
9. Sustainability (cost of life expectancy ownership, re-purposing of data)
10. Ensuring legal compliance (standards, regulations, codes).

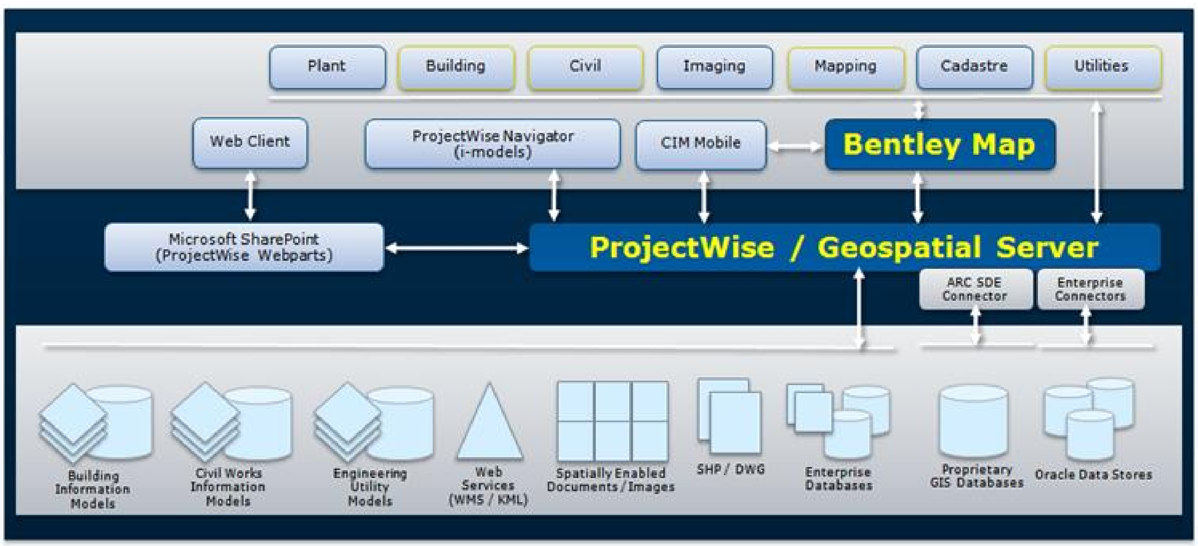


Figure 41. The Campus Information Management (CIM) Data Flow Diagram.

5.4 Product Training

USACE has an Enterprise License Agreement (ELA) that provides access to application training and online seminars to all USACE employees. The program helps large, multi-office and global organizations gain significant operational and competitive advantage, reduce annual software costs, and enjoy unrestricted access to comprehensive software and learning programs.

For more information on the USACE ELA, reference the USACE ELA website.

To find specific courses, reference the Learning Paths website. This will help you understand the flow of training and how some training courses are prerequisites to others. This is a tool that will help you understand Bentley's BIM and related software solutions and achieve short and long term goals.

- USACE ELA website: https://cadbim.usace.army.mil/bentleyela
- Training and Learning with Bentley website: http://www.bentley.com/en-US/Training/
- Learning Paths website: http://www.bentley.com/en-US/Training/Products/Resources/Courses/Find+Courses.htm

5.5 Online Seminars

The Be Connected Online Seminar Series for Infrastructure Professionals is a convenient way to stay informed of the latest trends in infrastructure practice and technology, increase your skills, and gain learning units for professional development hours for professional association membership and licenses. It is an on-demand seminar series that provides a wide variety of content for infrastructure professionals across multiple disciplines and specific formats such as:

1. Bridges
2. Cadastre and Land Development
3. Communications
4. Electric and Gas Utilities
5. High Performance Buildings
6. Mining and Metals
7. Oil and Gas
8. Rail and Transit
9. Roads
10. Water and Wastewater.

- Be Connected: http://connected.bentley.com/about.aspx

5.6 User Community Conferences

Be Together is a user-and product-centric conference designed to engage specific user-communities as defined by our most active forums on the Be Communities website and most requested User Group content. Be Together it includes live, interactive product tours, hands-on workshops, project management techniques, interactive roundtables, panel discussions, and product tests drives. The event is an opportunity to meet other professionals and to extend your professional network.

- Be Together: http://www.bentley.com/en-US/Community/BE%20Conference/?skid=CEE_BE_TOGETH_SESSIONREG&MIG=%3cMIG_38493%3e

5.7 Social Networking

Be Communities is a social networking site for those in the architecture, engineering, construction, operations, and GIS communities with tools such as forums, blogs, a resource gallery, and a wiki for connecting, communicating, and learning from each other.

- Be Communities: http://communities.bentley.com/
- USACE BIM and CW-BIM Community: http://communities.bentley.com/communities/user_communities/usace_bim___cw-bim/default.aspx
- AskInga: http://communities.bentley.com/communities/other_communities/askinga/w/askinga/default.aspx

6 Interoperability Capabilities

Costs to the architectural, engineering and construction industry due to lack of software interoperability has been thoroughly documented. The solution goes beyond the DGN/DWG CAD problem. Bentley's interoperability platform includes the following key characteristics:

1. Embraces existing applications - direct data exchange supporting native formats such as Revit and analytical applications such as Visual Pro.
2. Synchronizes project information - ProjectWise Navigator's ability to perform BIM coordination with multiple file formats including Revit, AutoCAD, ESRI, InRoads and Bentley BIM products.
3. Generates integrated views of project information - such as the IFC data exchange, GSA concept design view and COBie.
4. Creates dynamic deliverables - such as; DGN, DWG, SKP, gbXML, IES, ISO15926, JT Open, IFC, PDF, aecXML, SDNF, SDSFIE, ArcSDE, KMZ, KML, CVS, MPP, XLS, TIN, and D45.
5. Provides client applications for extracting value from project information - *i*-model technology allows for measuring, navigating, visualizing status, querying of data, markups, rendering, clash detection, schedule simulation and other collaboration of many BIM (including Revit) and other types of files.

- Bentley Interoperability Platform White Paper: http://ftp2.bentley.com/dist/collateral/Web/Platform/WP_Interop_Platform.pdf

6.1 Interoperability and Open Standards

Bentley is committed to supporting the interoperability and free exchange of digital building information that architects, engineers, contractors, and owner-operators rely on to be successful in their businesses. Open standards benefit users by enabling seamless information flow, integrated processes, enhanced capabilities, and a project-wide approach to tasks. Bentley is an active supporter and participant in many standards initiatives and organizations for the building, plant, geospatial and civil industries.

Additional information can be found on the Bentley website.

- Commitment to Open Standards and Interoperability: http://www.bentley.com/en-US/Solutions/Buildings/Open+Standards+and+Interoperability.htm

6.1.1 IFC

IFC (Industry Foundation Classes) are a vendor-neutral data repository for BIM models including both geometry and properties of intelligent building objects and their relationships, thus facilitating the delivery of data for downstream applications for analysis.

Bentley Architecture is IFC2x3 Coordination View certified. For additional information on Bentley's work with buildingSMART and IFCs, please visit the Be Communities wiki site, IFC.

- buildingSMART Alliance: http://www.buildingsmartalliance.org/
- IFC2x3 Coordination View: http://www.bentley.com/en-US/Products/Bentley+Architecture/IFC2x3-certification.htm
- Be Communities wiki site, IFC: http://communities.bentley.com/Products/Building/w/Building__Wiki/ifc.aspx

6.1.2 COBie

COBie (Construction and Operations Building information exchange) is an initiative for transferring data to downstream applications for analysis. Bentley has participated in the development of COBie and COBie2. Bentley has successfully participated in the COBie challenges. These challenges were a part of the FM Handover Aquarium project, which is organized by the buildingSMART Alliance of North America and sponsored by the Engineer Research and Development Center of the US Army Corps of Engineers, the CAD Stelle Bayern, Staatliches Bauamt München (Germany) and Statsbygg (Norway). For additional information visit the FM Handover Aquarium and COBie2 Challenge.

- COBie: http://www.wbdg.org/resources/cobie.php

6.1.3 gbXML

In November of 2009, Bentley announced that it has added Green Building XML (gbXML) 0.37 schema support to Hevacomp products for energy design, analysis, and simulation. Hevacomp joins a growing number of gbXML-enabled Bentley products, which also include Bentley Architecture

V8*i*, Bentley Building Mechanical Systems V8*i*, Bentley speedikon Architectural V8*i*, and Bentley Tas Simulator V8*i*. gbXML schema was developed to facilitate the transfer of data stored in BIM models to analysis tools such as Hevacomp.

- gbXML: http://www.gbxml.org/

6.1.4 CIS/2

CIS/2 is a data exchange file format for structural steel project information, and has been implemented by steel design, analysis, engineering, fabrication, and construction software packages. The American Institute of Steel Construction has adopted CIS/2 as their standard format for electronic data exchange. CIS/2 files exported by analysis or design applications are typically imported into detailing programs to detail connections. The basis for CIS/2 files is the STEP file extension. RAMSteel, STAAD.Pro, and Structural Modeler support CIS/2 translation for its structural steel member information.

- CIS/2: http://www.cis2.org/
- Bentley CIS/2 Support White Paper: http://www.cis2.org/download/Bentley/cis2.html

6.2 Bentley i-models

An i-model is a "container" for semantically rich metadata and components with business properties, graphics, and relationships.

The basic characteristics of an i-model are:

1. The contents of an i-model are "self-describing"
   a. does not require specialized application logic to interpret its components
   b. there are no references to an external schema. any required schema is embedded in the i-model
   c. external references represented in standard, well understood mechanisms
2. An i-model includes its "provenance"
   a. specifies the source, date, state, scope and purpose for the information it contains

   b. records transformations applied to the content after being published from source content
   c. provenance provided at the file and component levels
3. An i-model is "secure"
   a. it is read-only
   b. it can have digital rights and digital signatures applied to it
4. An i-model may be created in multiple ways
   a. published from the native format of an application
   b. result from the transformation process on one or more i-model
5. A i-model is a snapshot of project content from known source(s), at a known point in time, in a known state, of a known scope and for a specified purpose.

- *i*-Model Overview: http://www.bentley.com/en-US/Products/ProjectWise+Navigator/i-model.htm

Annex 1: Bentley BIM Product Index

Information and data sheets about Bentley software products supporting USACE BIM implementation is available from the Bentley website at http://www.bentley.com/en-US/Products/All+Products/All+Products+Overview.htm.

Team Collaboration **ProjectWise Integration Server** Collaboration and Information Access for Distributed Teams **ProjectWise StartPoint** Entry-level Collaboration Based on Microsoft SharePoint **ProjectWise InterPlot** Publishing Solutions for Accurate and Intelligent Project Deliverables **SELECTserver** Streamlining License Management and Administration	Civil Engineer **GEOPAK Civil Engineering Suite** Civil Engineering Design and Analysis **InRoads Suite** Civil Engineering Design and Analysis
Project Management **MicroStation** Platform for 3D Modeling, Visualization and Drawing **ProjectWise Navigator** Dynamic Collaboration for Iterative Project Review **ConstructSim** Planning, Sequencing, Execution and Monitoring of Construction Activities **Bentley View** DWG, DGN and CAD File Viewer	Architecture **GenerativeComponents** Generative Design **Bentley Architecture** BIM for Architectural Design and Documentation **Bentley speedikon Architectural** BIM for Architectural Design and Documentation
Geospatial Engineer **Bentley Map** Full Featured Mapping Based on MicroStation **Bentley PowerMap** Mapping Based on Power Platform **Bentley Descartes** Raster Imaging and Manipulation **Bentley Cadastre** Create, Maintain, and Analyze Land and Property Information	Plumbing Engineer **Bentley Building Mechanical Systems** BIM for Design and Documentation of Air-handling and Plumbing Systems **PlantSpace Piping** MicroStation-Based Piping Design and Modeling Projects
Mechanical Engineer **Bentley Building Mechanical Systems** BIM for Design and Documentation of Air-handling and Plumbing Systems	Electrical Engineer **Bentley Building Electrical Systems** BIM for Design and Documentation of Building Electrical Systems

Structural Engineer	Energy Consultant
Structural Modeler BIM for Design and Documentation of Structural Systems **RAM Structural System** Structural Analysis and Design of Buildings **RAM Concept** Advanced Design of Reinforced and Post-tensioned Concrete Slabs and Mats **RAM Concrete** RAM Structural System's Productivity Tool for Analysis and Design of Concrete Structures **RAM Connection** Steel Connection Design **RAM Elements** Structural Engineer's Toolkit System **RAM Foundation** Productivity Tool for Analysis and Design of Pile Caps, Spread Footings, and Continuous Footings **RAM Frame** Productivity Tool for Lateral Analysis and Design **RAM Steel** Productivity Tool for Gravity Analysis and Design of Steel Structures **STAAD.Pro** Structural Analysis and Design Software **STAAD.foundation** Foundation Design **ProStructures** Structural Detailing and Fabrication for Steel and Concrete **ProConcrete** 3D CAD for Modeling, Detailing, and Scheduling **ProSteel** Structural Steel Detailing and Fabrication	**Hevacomp Simulator** Design and Simulation Interface to EnergyPlus **Hevacomp Electrical Designer** Electrical Design Software Suite **Hevacomp Mechanical Designer** Mechanical Design Software **Hevacomp Pro EP Cert** Fully Accredited Standalone CAD EPC Program **Bentley Tas Simulator** Industry-Leading Building Modeling and Simulation **Facility Engineer** **Bentley Facilities Planner** Track Corporate Assets from Deployment to Decommissioning **Bentley Facilities Manager** Author and Maintain Facilities-related Information in a Non-graphical (Windows) Environment **Bentley Facilities Inquirer** Access to Facilities Data via a Web Browser **Bentley Facilities Web Reports** Web Based Reports for Facilities Data, Including Dashboards, Report Scheduling, Ad-hoc Reports

Annex 2: Glossary of Bentley Terminology

AccuDraw: Design aid that evaluates parameters such as the current pointer location, the previously entered data point, the last coordinate directive, the current tool's needs, and any directive that has been entered with keyboard shortcuts or AccuDraw options. AccuDraw then generates the appropriate precision coordinates and applies them to the active tool.

AccuSnap: Capability that enhances many of the standard snap mode settings by displaying and automatically snapping to the next tentative snap point as you move the pointer over an element.

Building Information Modeling (BIM): A digital representation of physical and functional characteristics of a facility. As such, it serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life cycle from inception onward (Whole Building Design Guide, http://www.wbdg.org/bim/bim.php).

Building Information Modeling (also abbreviated as BIM): A process in which project participants are contributing to a shared coordinated model for design, construction and operations of a facility. The process involves both graphical modeling and business information management. This process supports the automation of drawings and reports, design analysis, construction schedule simulation and facilities management.

Building Massing Model: A simple planning model created with easy to manipulate shapes that have face recognition, very similar to sketch up model.

Cell: A complex element composed of a group of primitive or other complex elements that is stored in a cell library for repeated placement.

CIM: Campus Information Model, describing multiple BIMs along with GIS and Civil information.

Component: Materials that make up a part. For instance, a base plate part may consist of grout and steel plate components. A single component may be tied to many different parts. Component data can be used for quantity take-offs, specification sections based on CSI format and even cost data.

Corporate Dataset: Similar to the project dataset, but holds BIM data that is common to all projects and design teams.

DataGroup: A schema that defines building objects and instance data for modeling, drawings, making it available for schedules and reporting. Custom information can be defined to objects in a 2D or 3D.

Dataset: Information that describes the non-graphical and graphical data tied to the objects within the BIM.

DGN: A document file that contains one or more models. These models may be design models or sheet models.

DGNLib: A DGN file that contains data resources, such as cells, levels, and styles, that are shared throughout files and among users. Sometimes referred to as a DGNLib. The recommend file extension is ".dgnlib".

Discipline Master Model: A term for all the discipline-specific Floor Master Models referenced together to represent the structure.

ELA: Enterprise License Agreement; USACE-specific term for ELS.

ELS: Enterprise License Subscription.

Extraction: Cuts or views of the structure taken from Discipline Master Models. When the extraction is taken, a two dimensional view of the structure is obtained (floor plan, elevation, section, etc.). However, the extraction still contains links to the data embedded in the BIM model. If a change is made to the Discipline Master Model, the extraction will need to be regenerated.

Family: An organized group of parts within the TriForma Dataset Explorer. The Corps of Engineers dataset organizes the parts into families based on constructions systems such as "Exterior Walls," "Doors," or "Spaces."

Floor Master Model: A breakout of a structure's discipline-specific elements into floors. Breaking out a discipline's work into Floor Master Models allows architects/engineers to work simultaneously on various parts of a structure without waiting on another's work. For instance, one architect may begin working on the exterior shell of a building, while another architect works on the interior model of the first floor. If a structure is extremely complex, the need may arise to break the structure's Floor Master Models up into Zone Master Models.

i-model: A container for open infrastructure information exchange that enables bidirectional feedback in dynamic workflows. It can be information rich, reliable, and optimized for purpose.

Level Library: A file is used during the boot up of TriForma by configuration files to attach levels required for all parts within a dataset. It does not replicate the seed file levels needed to comply with the A/E/C CADD Standard. It is provided to make sure that no parts are placed without the proper level.

Master Model: A DGN file that references multiple design models for the purpose of review and data extraction.

Model File: In the BIM process, the model file contains a referenced Extraction and model file-specific information. It is recommended that Extractions not serve directly as model files, since if Extractions have to be regenerated, all model file-specific information added to the Extractions will be lost. See the A/E/C CADD Standard (version 4.0 or later) for more information (https://cadbim.usace.army.mil/cad).

Parts: Parts are the building blocks of a BIM. For example, doors and walls are parts of a building. Similarly, walls, slabs and pilings are parts of a flood control retaining wall. A part holds graphic and non graphic information about those objects. It contains component and extraction information. All Corps of Engineers Parts control and comply with the A/E/C CADD Standard.

Project Dataset: Resides within the Con_Docs project folder and contains all BIM data related to the specific BIM project.

Project Master Model: The project master model is a compilation of all Structure Master Models plus possibly Civil DTM files referenced together. The project master model file shows the entire project (e.g., all building Structure Master Models), rather than just a portion of the project (one building's Structure Master Model).

Project Template: A standard template folder and data structure used to begin USACE projects which utilize the Tri-Service Workspace. It holds the project dataset, the models, and the output. This is the BIM deliverable.

Reference File: A file that is being referenced from another “Master File”. It is usually included for viewing and review, but can be activated from the master for editing.

Seed File: A seed file is a file used to create a new file. A seed file is simply a file with as many default configuration settings completed for a project. The seed files provided in the Default Dataset have been created with the proper working units, color table, and many other settings complete. This does not mean that the seed file will have everything needed for all projects, but it is provided to clarify and simplify specific settings.

Sheet File: A sheet file is a CAD file that shows a selected view or portion of a model file within a referenced border sheet. Sheet Files are used to generate the plotted construction sheets. See the A/E/C CADD Standard for more information.

Structure Master Model: The structure master model is a compilation of all the discipline master models referenced together. The structure master model composes the entire structure.

Tri-Service Workspace: Configuration files and template that are uniquely developed to hold the Tri-Service BIM standards, datasets and the A/E/C CAD standards.

Workspace: The workspace is the framework for a set of folders and discipline application settings files that configures the TriForma interface and data management. This is used by the Corps of Engineers to gain consistent data when receiving BIM submittals and deliverables.

Zone Master Model: A zone master model is a breakout of a structure’s discipline-specific floor master model elements into zones or quadrants. This is only recommended for extremely complex structures.

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14. ABSTRACT
Building Information Modeling (BIM) technology has rapidly gained acceptance throughout the planning, architecture, engineering, construction, operations, and maintenance industries. The challenge for the US Army Corps of Engineers (USACE) is to extend BIM use beyond its basic labor- and time-saving benefits to become a fully realized information network that permanently transforms conventional business processes to unprecedented levels of efficiency and organization.

This document describes the current USACE strategic plan, reflecting progress made toward the goals of the original 2006 USACE BIM roadmap as published in Engineer Research and Development Center (ERDC) Technical Report TR-06-10 (October 2006). This update of the strategic roadmap focuses on fuller integration of BIM technologies into USACE planning, design, construction, and operations and maintenance (O&M) processes. It describes how USACE will meet or exceed the vision of its customers, including the Office of the Secretary of Defense (OSD), the Army, and the Air Force. The scope of this plan is BIM implementation within the business processes of the Military Construction (MILCON) and Civil Works programs, including processes for working with USACE industry partners and software vendors.

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modeling, planning, design, construction, operations and maintenance (O&M), Military Construction (MILCON), construction costs, building life cycle

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